Muelleria

Plant, Algal and Fungal Taxonomy & Systematics

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***Pterostylis xerophila* M.A.Clem.**
Source: State Botanical Collection
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Pterostylis xerophila is a member of subgenus *Oligochaetochilus* (Szlach.) Janes & Duretto. It is very rare in Victoria, known from only a few localities in the north-west of the state, where it is usually associated with rocky outcrops. It is known from similar habitats in South Australia.

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An overview of the *Thelymitra nuda* (Orchidaceae) complex in Australia including the description of six new species

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Introduction

Thelymitra J.R.Forst. & G.Forst. is a complex genus of orchids consisting of about 110 described species, several described natural hybrids and at least 10 undescribed taxa. It is concentrated in higher rainfall areas of temperate Australia, but a few species occur in tropical north-eastern Australia, about 20 species occur in New Zealand (14 endemic) and a few species occur in Indonesia, New Caledonia, New Guinea and the Philippines.

Taxonomic history and discussion

The complex of taxa surrounding *Thelymitra longifolia* J.R.Forst. & G.Forst. (the type species of *Thelymitra*) is vast, and probably includes about half the total number of species in the genus (Bates 1999). The first botanist to study the genus in any detail was Robert Brown (1810), who described three new species, which can be placed in the *T. longifolia* complex – *Thelymitra angustifolia* R.Br., *Thelymitra nuda* R.Br. and *Thelymitra pauciflora* R.Br. from eastern Australia. Lindley (1839–40 & 1840) described a further four new species in this group – *Thelymitra arenaria* Lindl., *Thelymitra graminea* Lindl., *Thelymitra macrophylla* Lindl. and *Thelymitra versicolor* Lindl. (the latter I regard as a synonym of *T. nuda*) – two species from the eastern states and two from Western Australia. Bentham (1873) took an extraordinarily conservative approach by recognising only *T. longifolia* as a valid species, while relegating *T. arenaria*, *T. graminea*, *T. nuda*, *T. pauciflora* and *T. versicolor* to synonymy under that species, *T. angustifolia* to synonymy under the unrelated *Thelymitra aristata* Lindl. and *T. macrophylla* as a taxon linking *T. aristata* to *T. longifolia*. Most botanists and authors that have dealt with the genus since Bentham acknowledged that there are several to many distinct species involved (e.g. Fitzgerald 1875–95, Nicholls 1969, Jones 1988, Clements 1989,

Abstract

The *Thelymitra nuda* J.R.Forst. & G.Forst. complex is defined as a group and an overview of the Australian members is presented. Six new species, *T. alcockioe* D.L. Jones ex Jeanes, *T. alpina* Jeanes, *T. glaucophyllo* R.J. Bates ex Jeanes, *T. poludoso* Jeanes, *T. petrophilo* Jeanes and *T. queenslandica* Jeanes, are described and illustrated. The key diagnostic characters are discussed where relevant. Information on distribution, habitat, flowering time, pollination biology and conservation status is given for all taxa. A dichotomous key is provided.

Key words: *Thelymitro*, sun orchids, taxonomy, diagnostic features.

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Bernhardt 1993, Backhouse & Jeanes 1995, Jones & Clements 1998b, Jeanes 2004 and Bates 2010) resulting in a steady stream of new taxa being described.

Taxa in the *T. longifolio* complex generally have unspotted blue flowers (less often white or pink) varying in size from about 10 mm to 50 mm in diameter when fully open. The post-anther lobe of the column is tubular, variously inflated, usually smooth on the dorsal surface, variously open on the ventral side and entire, emarginate or deeply bifid at the apex. The auxiliary lobes are at most rudimentary, consisting of a pair of tiny incurved spurs on the lower apical margin of the post-anther lobe, or more often completely absent. The two finger-like lateral lobes extend forward from the column wing, one on each side of the anther and just below the post-anther lobe. These may be more or less straight, curved gently or bent upwards at right angles near the middle. Each lateral lobe has a tuft of white hairs (less often yellow or mauve) that may be elongate resembling a toothbrush or short and more or less terminal resembling a mop.

Thelymitro longifolio appears to be endemic to New Zealand as I have seen no specimens collected outside that country that are a good match for the type material. Australian members of the *T. longifolia* complex are often divided conveniently, but rather arbitrarily, into two smaller complexes on the basis of flower size and pollination biology. Members of the so-called *T. paucifloro* complex have small flowers (perianth segments usually to 10 mm long, sometimes as long as 12 mm and rarely reaching or exceeding 15 mm) that are usually unscented, generally autogamous and often also cleistogamous. This group has been dealt with elsewhere by the current author (Jeanes 2004). Members of the so-called *T. nuda* complex generally have larger flowers (perianth segments on mature plants are usually more than 15 mm long and sometimes as long as 25 mm) that open more readily, are often scented and are usually pollinated by native bees (melittophilous). A full revision of the *T. nuda* complex has not been attempted at this time as three informal taxa within the group were recently recognised for Western Australia (Hoffman & Brown 2011) and possibly others for South Australia (Bates 2011). I have not had an opportunity to study these taxa in the field nor examined herbarium material of them.

The *T. paucifloro* and *T. nudo* complexes are probably artificial as several taxa could be placed in either group based on flower size and *T. molvino* appears to produce both insect-pollinated and autogamous clones. Also, initial phylogenetic studies based on molecular analyses do not support either of these complexes as being natural groups (M.A.Clements pers. comm.).

At the outset of this study, nine species were recognised in the *T. nudo* complex in Australia – *Thelymitro oggericola* D.L.Jones, *Thelymitro frogrons* D.L.Jones & M.A.Clem., *T. graminea*, *Thelymitra gronitoro* D.L.Jones & M.A.Clem., *Thelymitro gregorio* D.L.Jones & M.A.Clem., *Thelymitra imbricato* D.L.Jones & M.A.Clem., *T. macrophyllo*, *Thelymitra megcalyptra* Fitzg. and *T. nudo*. It became evident during this study that there are many more than just these nine species present. The differences between the species are often subtle and may only become evident after close scrutiny of the whole above-ground parts of fresh plant material with a hand lens or a microscope.

Traditionally, the column has provided the main suite of characters used to distinguish between the species in *Thelymitra*. However, for this study of the *T. nudo* complex, vegetative characters, phenology and habitat information have proven more important for distinguishing many of the species. For example, *Thelymitra glaucophylla* R.J.Bates ex Jeanes can be identified with a high degree of confidence from mature leaves alone. *Thelymitra paludosa* Jeanes is similar morphologically to *T. mocrophyllo*, but usually grows in wetter substrates and generally flowers later (although there is some overlap). Most species in the complex exist as solitary individuals producing only a single replacement tuber each season. Others such as *T. gregario* produce small dense clumps by vegetative reproduction (Jones & Clements 1998a).

The various members of the *T. nudo* complex have a propensity to hybridise with other *Thelymitra* species, both inside and outside the group (Weber & Entwisle 1994; Jones 2006), making positive identification of some plants extremely difficult.

Explanation of the terminology used

The genus *Thelymitra* is unusual in the Orchidaceae in that the six perianth segments generally differ very

little from each other in terms of size, shape and ornamentation. The labellum does not bear any hairs, calli, glands, ridges, lobes, teeth or fringes and is apparently not involved in pollination. Since the perianth is virtually actinomorphic and generally lacks characters by which to distinguish the species, traditionally the structure of the column has supplied most of these distinguishing characters. Over the years a terminology has evolved to describe the column structure in *Thelymitra*, but some of these terms are poorly understood and some have never been defined adequately. Below is an explanation of some of the terms commonly used in this paper; most have a traditional usage, although this has often not been well understood.

***Column* (gynostemium):** The column is exposed in the centre of the flower; it lacks a free filament and style, is short and thick and broadly winged from below the stigma to the level of the anther or beyond. The apex is usually 3–5-lobed and is often ornamented with hairs, fringes, teeth, calli, glands, tubercles or lobes. In members of the *T. nuda* complex the apex of the column is more or less tri-lobed with hairs adorning the two lateral lobes.

***Post-anther lobe* (mid-lobe):** This structure protrudes beyond the point of insertion of the anther and of the lateral lobes, and it is usually of a different colour to the rest of the column. It has a complex vascular supply always associated with that of the functional anther and could be regarded as an outgrowth of the filament and the lateral lobes. In some species it is represented only by a short flap or a band of small calli crowded across the back of the anther. In most species it extends well beyond the anther with a free margin that may be plain, undulate, toothed, notched or variously ornamented with tubercles. At its maximum development (such as in the *T. nuda* complex) it forms a tubular hood that is variously open on the ventral side and overhangs and obscures the anther. The apex of this tube is usually bright yellow and is often variously cleft into two distinct lobes that have shallowly toothed and often thickened margins. In the literature the post-anther lobe has often been described as 'inflated', particularly in reference to some members of the *T. pauciflora* and *T. nuda* complexes. In this account the term inflated is used in relation to those taxa in which the shape of the post-anther lobe is noticeably bulbous and is discontinuous with the shape of the column lower down. This is often obvious when viewing the column in profile, but is usually more evident when viewing it from above and behind. The orifice at the apex of the post-anther lobe is usually more or less circular when viewed from the front, but in some species it is oval due to dorsal compression.

***Lateral lobes* (column-arms or lateral staminodes):** These two structures lie one each side of the post-anther lobe and of the anther and extend forward or upward and often converge. They are each supplied by a single unbranched vascular bundle and are thought to represent staminodes. They may be flat and ribbon-like, terete and finger-like, straight, curved, twisted spirally or bent sharply, and are usually ornamented with lobes, teeth, tubercles or hairs. The lateral lobes are finger-like and trichomate in members of the *T. nuda* complex, but may be straight, curved gently, bent sharply, parallel or convergent.

***Trichomes* (hairs):** These structures are present on the lateral lobes of many *Thelymitra* species, including those in the *T. nuda* complex. They are each 1–2 cells wide throughout their length and may be thickened and glandular at the apex (Weber & Bates 1986). In the *T. nuda* complex they usually extend along nearly the entire length of the lateral lobe in a toothbrush-like arrangement, or more rarely concentrated in the distal half in a more mop-like arrangement. The hairs are usually white in the *T. nuda* complex.

***Auxiliary lobes* (accessory lobes or side lobules):** Several species of *Thelymitra* (e.g. members of the *Thelymitra canaliculata* R.Br. complex) have a pair of distinct lobes between the post-anther lobe and the lateral lobes. These have no vascular strand and are most accurately described as being part of a tripartite post-anther lobe. They tend to be fleshy with irregularly jagged margins and sometimes have small surface tubercles. In the *T. nuda* complex the auxiliary lobes are often completely absent or they may be reduced to a pair of small incurved spurs or bumps on the distal margin of the post-anther lobe.

***Anther*:** In *Thelymitra*, the anther is usually small, ovoid, and situated entirely between the column wings. The connective extends beyond the pollinia into an apical beak-like projection of varying size. The anther may be entirely above the stigma or variously obscured behind it. In the *T. nuda* complex the anther is usually

inserted about halfway along the column at anthesis and is most often entirely above the stigma.

***Pollinarium*:** In *Thelymitra* the pollinarium consists of four pollinia (in two groups of two) attached directly, or by a short caudicle, to a terminal viscidium.

***Pollinia*:** In *Thelymitra* the pollinia consists of pollen grains in monads or tetrads. In the *T. nuda* complex the pollen grains are usually bound tightly and the pollinarium is removed as a single unit by pollinators.

***Stigma*:** The stigma in *Thelymitra* is more or less bi-lobed at the apex, usually quadrate or transverse-elliptic in shape and located at the base of the column on a thick stalk.

Materials and methods

This paper is the result of a qualitative and quantitative study of the pertinent type material (or photographic reproductions thereof), all the available herbarium specimens (both dry and spirit-preserved) from AD, BM, BRI, CANB, E, HO, MEL, NSW, P, PERTH, QRS, SUNIV and WELT, and freshly collected specimens of all taxa except *T. queenslandica*, which were vouchered and deposited at the relevant herbaria. Orchid taxa in general, and *Thelymitra* taxa in particular, are much more readily identified from fresh living material where characters of the perianth, the column, flower colour and fragrance are still intact. Familiarity with the taxa gained from field study and the study of freshly collected specimens sent to me by field operatives has made the identification of dried and spirit-preserved herbarium material (including type specimens) much easier.

When collecting *Thelymitra* for study it is essential that the entire above ground parts of the plant be taken, with the majority of the material being preserved in spirit (a good preserving medium is ethanol, water and glycerol in the ratio 1750:750:125). Plants preserved in the pressed state are often difficult to identify to species level in the absence of additional information. To aid identification it is recommended that one or two flowers on each specimen have the perianth removed before pressing so that the column is not obscured. Spirit-preserved specimens, on the other hand, are generally much more easily identified to species level. The observation of plants growing *in-situ* is the ideal method of study for *Thelymitra* in general, and often it is only by this method that cryptic new species can be identified. For this reason the importance of field work in the study of species complexes within *Thelymitra* cannot be overstated and should form an integral part of any future studies of the group or its individual members. It is likely that other taxa worthy of recognition exist within this large and diverse complex, but adequate information and collections of these are lacking at present.

Taxonomy

1. *Thelymitra gregaria* D.L.Jones & M.A.Clem., *Orchadian* 12(7): 327 (1998)

***Type*: VICTORIA.** Chatsworth Rd, Derrinallum, 11.x. 1997, *D.L. Jones 15585 & E. Foster* (holotype CANB 990888; isotypes AD, MEL 2089285, MEL 2089286, NSW!).

Illustrations: Backhouse & Jeanes (1995) page 355 (as *Thelymitra* sp. aff. *nuda*); Jeanes & Backhouse (2006) page 207; Jones (2006) page 230.

Glabrous terrestrial *herb*, usually growing in dense clumps. *Tubers* ovoid to obloid, 1–2 cm long, 8–10 mm wide, fleshy. *Leaf* linear to linear-lanceolate, 5–12(–18) cm long, 5–12 mm wide, erect, canaliculate, fleshy, dark green to yellowish with a purplish base, ribbed abaxially, sheathing at base, lower margins minutely denticulate, apex acute. *Scape* 9–20 cm tall, 1–2.5 mm diam., moderately stout, straight, usually purplish, often pruinose. *Sterile bracts* usually 2, rarely 1 or 3, linear-lanceolate, 13–45 mm long, 3–8 mm wide, closely sheathing, acute to acuminate, green and purplish, often pruinose. *Fertile bracts* ovate-acuminate to obovate-acuminate, 5–24 mm long, 3–7 mm wide, closely sheathing the pedicels, green and purplish, often pruinose. *Pedicels* 4–10 mm long, slender. *Ovary* cylindric to narrow-obovoid, 3–10 mm long, 1.5–4 mm wide. *Flowers* 1–6, 20–40 mm across, dark violet-blue to purple with darker longitudinal veins, opening freely on mild to warm days, scented. *Perianth segments* 10–20 mm long, 5–10 mm wide, concave, often shortly apiculate; *dorsal sepal* ovate to elliptic, often cucullate, obtuse; *lateral sepals* ovate to lanceolate, obtuse to acute; *petals* ovate to elliptic, obtuse; *labellum* obovate, acute to obtuse. *Column* erect from the end of ovary, 5–7 mm long, 2.5–3.5 mm wide, pink, blue or purplish; *post-anther lobe* hooding the anther, 2–3.3 mm

Key to members of the *Thelymitra nuda* complex in Australia

1 Plant short and stocky; inflorescence rarely exceeding 20 cm and often considerably shorter 2

1: Plant tall and often slender; at least some mature plants with the inflorescence exceeding 20 cm tall 4

2 Leaf erect, more or less straight, usually only half the height of the inflorescence; flowers rich purple or mauve; grassland habitats of Victoria only ..... **1. *T. gregaria***

2: Leaf curving away strongly from the inflorescence, usually as long as distance from ground to lowest flower and often longer than entire inflorescence; flowers white or pale blue; rock outcrops of Tasmania and Western Australia 3

3 Perianth segments to 14 mm long; plants solitary; flowers usually pale blue, sometimes white; post-anther lobe brown or orange with a yellow apex; flowers late October to December; Tasmania only ..... **2. *T. aggericala***

3: Perianth segments >14 mm long at least on some mature specimens; plants forming clumps; flowers usually white, sometimes pale blue; post-anther lobe usually all yellow; flowers September and October; Western Australia only ..... **3. *T. granitara***

4 Leaf usually as long as distance from ground to lowest flower and often exceeding height of inflorescence 5

4: Leaf usually only half height of inflorescence or less 7

5 Leaf fleshy, canaliculate; post-anther lobe entire to emarginate, often entirely red or yellow; lateral lobes toothbrush-like, glabrous only at the very base; Western Australia only ..... **4. *T. petraphila***

5: Leaf thin-textured, strap-like, canaliculate at base only; post-anther lobe bilobed at apex, usually brown or purplish with a yellow apex; lateral lobes mop-like, glabrous in lower half; Queensland and New South Wales only 6

6 Flowers usually pale blue, pink or mauve; sterile bracts usually 2; mostly found on rocks growing with the lithophytic orchid *Thelychiton kingianus*; flowers August to October; south-east Queensland and New South Wales ..... **5. *T. fragrans***

6: Flowers dark blue to purplish; sterile bracts usually 3; plants terrestrial; flowers mostly June to September; northern Queensland only ..... **6. *T. queenslandica***

7 Perianth segments in mature plants rarely exceeding 18 mm long 8

7: Perianth segments in most mature plants exceeding 18 mm long 12

8 Inflorescence, basal part of the leaf and bracts often a striking reddish purple in colour; whole plant sometimes glaucous; mallee habitats of South Australia and Victoria ..... **7. *T. alcackiae***

8: Inflorescence, leaf and bracts predominantly green, sometimes with some minor purplish suffusions; plant not glaucous 9

9 Flowers pale purplish blue; perianth segments strongly imbricate; grassland habitats of Tasmania ..... **8. *T. imbricata***

9: Flowers dark purplish blue to violet; perianth segments imbricate at base only 10

10 Post-anther lobe not strongly inflated, compressed dorsally in distal half; lateral lobes inserted *c.* 1 mm from apex of post-anther lobe; hairs on lateral lobes not embracing apex of post-anther lobe; swamp margins of south-west Western Australia ..... **9. *T. paludosa***

10: Post-anther lobe strongly inflated, not compressed dorsally in distal half; lateral lobes inserted c. 0.5 mm from apex of post-anther lobe; hairs on lateral lobes embracing apex of post-anther lobe; sclerophyll forests 11

11 Post-anther lobe v-notched at apex; south-eastern Australia ..... **10. *T. nuda***

11: Post-anther lobe entire or emarginate at apex; Western Australia only ..... **11. *T. graminea***

12 Leaf mostly pale green with a whitish bloom, often senescent at anthesis; flowers pale blue, mauve or white; perianth segments thin-textured, papery; South Australia only ..... **12. *T. glaucaphylla***

12: Leaf mostly dark green lacking a whitish bloom, usually not senescent at anthesis; flowers usually dark blue to purplish; perianth segments thick-textured, not papery 13

Key to members of the *Thelymitra nuda* complex in Australia cont.

13 Leaf often >15 mm wide in mature plants; lateral lobes inserted c. 1 mm from apex of post-anther lobe; hairs on lateral lobes usually clear of apex of post-anther lobe; Western Australia only ..... **13. *T. macrophylla***

13: Leaf to 15 mm wide in mature plants; lateral lobes inserted c. 0.5 mm from apex of post-anther lobe; hairs on lateral lobes often touching apex of post-anther lobe; south-eastern Australia only **14**

14 Post-anther lobe compressed dorsally, orifice oval, distal margin usually with two forward-pointing teeth; montane and subalpine habitats; flowers mostly December to February ..... **14. *T. alpina***

14: Post-anther lobe barely compressed dorsally, orifice more or less round, distal margin lacking two forward-pointing teeth; lowland habitats; flowers mostly September to October ..... **15. *T. megcalyptra***

long, 1.3–2 mm wide, tubular, inflated, gently curved, brownish with a blackish sub-terminal collar, narrowed basally, apex slightly expanded, yellow, shallowly bilobed (lobes 0.5–1.5 mm long), apical margins sinuate; *auxiliary lobes* absent; *lateral lobes* converging, 0.8–1.5 mm long, digitiform, obliquely erect, each with a toothbrush-like arrangement of white hairs, the individual hairs 0.7–1 mm long. *Anther* inserted towards apex of column, ovoid, 2.3–2.8 mm long, 1.5–2 mm wide, the connective produced into a beak 0.4–0.6 mm long; *pollinarium* c. 2 mm long; *viscidium* circular to elliptic, c. 0.5 mm diam.; *pollinia* white, with coherent pollen. *Stigma* situated at base of column, ovate-quadrate, 1.5–2.5 mm long, 1.5–2.5 mm wide, margins irregular. *Capsules* obovoid, 8–12 mm long, 6–8 mm wide, erect, ribbed, often reddish. (Fig. 1a)

***Selected specimens examined*: VICTORIA.** Darlington–Camperdown Rd, 5 km SSE of Darlington PO, 15.x.1977, *G.J. Hirth s.n.* (MEL 1513210); Werribee, 18.x.1890, *A. Morrison s.n.* (CANB 367971); Western Plains region: Vite Vite, 11.x.1997, *D.L. Jones 15599 & E. Foster* (CANB 9908897); Western Highlands region: Woorndoo, roadside reserve just N of town, 11.x.1997, *D.L. Jones 15595 & E. Foster* (CANB 9908893); Western Plains region: Vite Vite, 4.xi.1992, *E. Foster DLJ10636* (CANB 9702502); Western Plains region: Vite Vite, 16.xi.2000, *D.L. Jones 17698 & K.J. Fitzgerald* (CANB 631092); Corangamite District: Chatsworth Road, 8 km WNW of Derrinallum, 19.x.1991, *J.A. Jeanes s.n.* (MEL 2011687); Corangamite District: About 8 km WNW of Derrinallum beside Chatsworth Rd, 4.x.1999, *A. & B. Tindall JAJ678* (MEL 2172992); Grassland reserve near Vite Vite railway siding, 4.x.1999, *A. & B. Tindall JAJ679* (MEL 2173010); Vite Vite Railway Reserve, 17.x.2001, *J.A. Jeanes 1172* (MEL 2172997); Beside Chatsworth Rd c. 5 km WNW of Derrinallum, 8.x.1999, *J.A. Jeanes 570, C. & M. Trigg* (MEL 2172972); Shelford-Mt Mercer Rd, c. 5 km N of the Shelford–Rokewood Rd, 26.ix.2002, *J.A. Jeanes 1223 & W.A. Gebert* (MEL 2173005).

***Distribution and habitat*:** Endemic to Victoria and apparently confined to the Victorian Volcanic Plain Region (Conn 1993), mostly in the vicinity of Derrinallum, Woorndoo, Willaura and Shelford, with numerous old collections from the basalt plains near Melbourne probably also referable to this species. Grows in tussock grassland on rich red-brown loams derived from basalt. Altitude: 20–150 m. (Fig. 2a)

***Conservation status*:** Of limited distribution, not reserved and most likely endangered. Suggest 3E by criteria of Briggs and Leigh (1996) and Endangered (E) by criteria of IUCN (2011).

***Flowering period*:** Late September to early November.

***Pollination biology*:** The easily spreading perianth, functional viscidium, coherent pollen and sporadic production of seed capsules would suggest that this species is entomophilous.

***Notes*:** *Thelymitra gregaria* is a distinctive species characterised by its grassland habitat, short, stocky, clumping habit, short, broad leaf and the large, freely opening dark purple or mauve flowers that have prominent darker longitudinal striations.

Several old pressed collections from the basalt plains to the west of Melbourne (particularly from St Albans) appear to be of this species, but since it is almost certainly extinct in the region, it is unlikely that this will ever be verified by the examination of living material.

Thelymitra gregaria is known to hybridise readily with *Thelymitra exigua* Jeanes wherever the two species grow together and, near the type locality, *T. gregaria* is also known to hybridise with *Thelymitra antennifera* (Lindl.) Hook.f., yielding plants with flowers indistinguishable from *Thelymitra* ×*macmillanii* F.Muell.

2. *Thelymitra aggericola* D.L.Jones, *Orchadian* 12(11): 517 (1999)

***Type:* TASMANIA.** Just S of Rebecca Ck, near Temma, 4.xi.1998, *D.L. Jones 16160, M. Garratt, L. Rubenach, J.E. & A. Wapstra* (holotype CANB 605802, isotypes CANB!, AD, HO!, MEL 2089289).

Illustrations: Jones *et al.* (1999) pages 260 & 262; Jones (2006) page 229.

Glabrous terrestrial *herb*. *Tubers* ovoid to obloid, 6–20 mm long, 3–6 mm wide, fleshy. *Leaf* linear to linear-lanceolate, 7–20(–30) cm long, 4–10(–15) mm wide, erect, curved, thin-textured to fleshy, canaliculate, dark green with a purplish base, ribbed abaxially, sheathing at base, apex acute. *Scape* 5–15(–30) cm tall, 1.2–2.8 mm diam., straight, green or purplish. *Sterile bract* usually solitary, rarely 2, linear-lanceolate, 1.5–3(–6) cm long, 4–7 mm wide, closely sheathing, green or purplish, acute to acuminate. *Fertile bracts* ovate-acuminate to obovate-acuminate, 5–15(–20) mm long, 3–7 mm wide, green or purplish, sheathing the pedicels. *Pedicels* 1.5–6 mm long, stout to slender. *Ovary* cylindric to narrow-obovoid, 5–10 mm long, 2–3.5 mm wide. *Flowers* 1–7(–10), 20–30 mm across, usually white to pale blue, opening freely in warm weather. *Perianth segments* 8–14 mm long, 3.5–9 mm wide, concave, apex acute to obtuse, often shortly apiculate; *dorsal sepal* ovate; *lateral sepals* lanceolate to ovate, slightly asymmetric; *petals* ovate; *labellum* elliptic to oblanceolate, often shortly stalked, usually narrower than other segments. *Column* erect from the end of ovary, 4.5–6 mm long, 2–3.5 mm wide, white to pale blue or pink; *post-anther lobe* hooding the anther, 2.5–3 mm long, 1.3–2.5 mm wide, tubular, slightly inflated, gently curved through c. 90°, brownish, apex yellow or occasionally bright orange, shallowly bilobed, lobes irregular; *auxiliary lobes* often present as 2 tiny incurved spurs on the lower apical margin of the post-anther lobe; *lateral lobes* converging, 1.3–2 mm long, digitiform, porrect at base, curved upwards, each with a toothbrush-like arrangement of white hairs along most of their length, the individual hairs 0.7–1 mm long. *Anther* inserted towards apex of column, ovoid, 2–2.8 mm long, 1.3–2 mm wide, the connective produced into a beak 0.5–0.7 mm long; *pollinarium* c. 2 mm long; *viscidium* more or less circular, c. 0.6 mm diam.; *pollinia* white with mealy, friable pollen. *Stigma* situated at base of column, ovate-quadrate, c. 2 mm long, c. 2 mm wide, margins irregular. *Capsules* obovoid, 10–15 mm long, 4–6 mm wide, erect, ribbed. (Fig. 1b)

***Selected specimens examined*: TASMANIA.** Arthur River, Rebecca Lagaon, 4.xi.1998, *H. & A. Wapstra* (HO 500051); Arthur River Road, Little Sundawn Creek, 3.xi.1999, *H. & A. Wapstra JAJ675* (MEL 2172982); 11.2 km S of Arthur River, towards Temma, 4.xi.1998, *D.L. Jones 16149 & M. Garrett* (CANB 6057911); 10.7 km S of Arthur River, just S of Nelsons Bay River, 4.xi.1998, *D.L. Jones 16143 & M. Garrett* (CANB 6057851); 8.7 km S of Arthur River Bridge, towards Temma, 4.xi.1998, *D.L. Jones 16134, M. Garrett, H. Wapstra, A. Wapstra & L. Rubenach* (CANB 6057761); Rebecca Creek, 5.xi.1990, *D.L. Jones 7033 & C.H. Broers* (CANB 9614130); c. 3 km E of West Paint, 5.xi.1990, *D.L. Jones 6995 & C.H. Broers* (CANB 9614092); Mount Brown, Storm Bay, 4.xii.1983, *A. Moscal 4627* (HO 401913); Tasman Peninsula, Mt Brown Reserve, 14.xii.1995, *H. Wapstra DLJ14738* (CANB 9609811); Recherche, xii.1901, *F.A. Rodway 8573* (AD 99405117).

***Distribution and habitat*:** Apparently endemic to Tasmania, mostly in the north-western region near Arthur River, but also with a couple of disjunct collections from near-coastal areas of the south-east. Grows in shallow soil in pockets and crevices of rocky outcrops in low heathland, or occasionally in open heathland on shallow dark sandy loams. Altitude: 3–180 m. (Fig. 2b)

***Conservation status*:** Rare overall but sometimes locally common and conserved. Suggest 3RC by criteria of Briggs and Leigh (1996) and Near Threatened (NT) by criteria of IUCN (2011).

***Flowering period*:** October to December.

***Pollination biology*:** In spite of the freely opening flowers, the abundance of seed capsules produced by this species would suggest that it is facultatively autogamous.

***Notes*:** *Thelymitra aggericola* is readily distinguished from all other related species by a combination of features including its generally short stature, strongly curved leaf that is often as long as or longer than the inflorescence and the rather small, pale-coloured, freely opening flowers.

3. *Thelymitra granitora* D.L.Jones & M.A.Clem., *Orchadian* 12(7): 326 (1998)

***Type*: WESTERN AUSTRALIA.** Near Torbay Hill, Torbay, 18.x.1988, *D.L. Jones 3250, M.A. Clements & R. Heberle* (holotype CANB 8806912, isotype PERTH!).

Illustrotions: Jones & Clements (1998a) page 328; Hoffman & Brown (1998) page 264; Jones (2006) page 235; Brown et *al.* (2008) page 329, C; Hoffman & Brown (2011) page 318.

Glabrous, usually clumping, terrestrial *herb. Tubers* ovoid to obloid, 1–2 cm long, 5–8 mm wide, fleshy. *Leaf* linear-lanceolate, 7–15 cm long, 5–13 mm wide, erect at base, strongly curved away from inflorescence, canaliculate, fleshy, dark green to purplish with a purplish base, ribbed abaxially, sheathing at base, apex acute. *Scape* 6–20 cm tall, 1.5–3 mm diam., stout, straight, often pruinose, green or purplish. *Sterile bracts* 1–3, linear-lanceolate, 2–6.5 cm long, 4–9 mm wide, closely sheathing, acute to acuminate, green to purplish, often pruinose. *Fertile brocts* ovate-acuminate to obovate-acuminate, 5–30 mm long, 3–8 mm wide, sheathing the pedicel, green to purplish, often pruinose. *Pedicels* 3–9 mm long, slender. *Ovory* narrow-obovoid, 5–10 mm long, 1.5–3.5 mm wide. *Flowers* 2–8, 17–35 mm across, usually pale blue or white, opening only in hot weather. *Perionth segments* 7–17 mm long, 2–5 mm wide, concave, sometimes shortly apiculate, distal margins often incurved; *dorsal sepol* narrowly oblong-ovate, acute; *loteral sepals* narrowly oblong-ovate, slightly asymmetric, acute to acuminate; *petols* narrowly oblong-obovate, acute; *lobellum* narrowly oblong-obovate, acute, often slightly smaller than other segments. *Column* erect from the end of ovary, 6–7.5 mm long, 2.5–3 mm wide, white to pale blue; *post-onther lobe* hooding the anther, 1.5–2.5 mm long, 1.5–2.5 mm wide, tubular, slightly inflated, more or less erect at base, gently curved, narrowed at base where dark blue, expanded distally into a rounded hood, apex shallowly bilobed, yellow; *auxiliory lobes* absent; *loterol lobes* converging, 1.3–1.8 mm long, 0.4–0.6 mm wide at base, narrowing and digitiform in the distal two-thirds, erect or porrect at base, curved upwards, each with a dense toothbrush-like arrangement of white hairs along upper ½ to ¾ of their length, the individual hairs 0.8–1 mm long. *Anther* inserted about midway along column, ovoid, 2.5–3 mm long, 1.3–2 mm wide, connective produced into a beak 0.6–0.8 mm long; *pollinorium* 1.8–2.2 mm long; *viscidium* elliptic, c. 0.3 mm long; *pollinio* white with friable, mealy pollen. *Stigmo* situated at base of column, quadrate, c. 2.5 mm long, c. 2.5 mm wide, margins entire or slightly irregular. *Copsules* obovoid, 10–16 mm long, 4–6 mm wide, erect, ribbed. (Fig. 1c)

***Specimens examined*: WESTERN AUSTRALIA.** Cape Leeuwin, 2.x.1982, *G.J. Keighery 5356* (PERTH 271977); Eyre District: Coastal granite headlands overlooking mouth of the Thomas River, 15.ix.1996, *C.J. French 281* (CANB 627194); South Coast. Recherche Archipelago. Pasco Island, 12.xi.1950, *J.H. Willis s.n.* (MEL 114557); Summit of Mt Belches on Duke of Orleans Bay, c. 42 miles (67 km) E of Esperance, 30.xi.1950, *J.H. Willis s.n.* (MEL 1549685); Cape Leeuwin near old waterwheel, 22.x.2000, *J.A. Jeanes 867 & C. French* (MEL 2093582, MEL 20935B3 & PERTH); Darling District: 12.9 km SW from Boyup Brook on road to Bridgetown, 9.x.1991, *D.L. Jones 8276* (CANB 610411); Nature Reserve on Highway #1 c. 0.9 km E of Tindale Road; c. 34 km W of Denmark by road, 4.x.2001, *J.A. Jeanes 1165 & S.A. Jeanes* (MEL 2172938, MEL 2172939 & PERTH).

***Distribution and habitat*:** South-western Western Australia mostly in a near-coastal strip between Margaret River and Israelite Bay, with disjunct more inland occurrences near Pinjarra and Boyup Brook. Grows in shallow soil in pockets and crevices of granite outcrops on coastal headlands or rarely further inland. Soils are dark loams and gravelly loams derived from granite. Altitude: 10–50 m. (Fig. 2c)

***Conservation status*:** Widespread, sometimes locally common and conserved.

***Flowering period*:** September to October.

***Pollination biology*:** This species is apparently facultatively autogamous.

***Notes*:** *Thelymitro granitoro* is characterised by its clumping habit, short curved leaves, short stout inflorescence and relatively large white to pale blue flowers that open tardily.

4. *Thelymitra petrophila* Jeanes, *sp. nov.*

***Type*: WESTERN AUSTRALIA.** Coolgardie District: Ularring Rock, SW of Menzies on road to Mulline, 26.ix.1991, *D.L. Jones 7945, C.H. Broers, M.A. Clements & B.E. Jones* (holotype CANB 9609547; isotypes AD 99642411, BRI 660020, MEL 250472, PERTH 4563697 & NSW!).

Illustrotions: Hoffman & Brown (1998) page 268 (as *Thelymitro* aff. *mocrophylla*); Brown et *ol.* (2008) page 333, A; Hoffman & Brown (2011) page 324.

Solitary or clumping, glabrous, terrestrial *herb. Tubers* ovoid, 1–2.5 cm long, 5–10 mm wide, fleshy. *Leof* linear to linear-lanceolate, 10–30(–60) cm long, 4–8(–12) mm

wide, erect, canaliculate, leathery, ribbed abaxially, light green with a purplish base, sheathing at base, apex acute to acuminate. *Scape* 10–40(–70) cm tall, 1–3.5 mm diam., straight, green to purplish. *Sterile bracts* usually 2, occasionally 3, linear to linear-lanceolate, 1.5–7 cm long, 3–10 mm wide, closely sheathing, acute to acuminate, green to purplish. *Fertile bracts* ovate-acuminate to obovate-acuminate, 5–22 mm long, 3–6 mm wide, sheathing the pedicels, green to purplish. *Pedicels* 2–10 mm long, slender. *Ovary* cylindric to narrow-obovoid, 5–10 mm long, 1–3 mm wide. *Flowers* 2–10(–15), (15–)20–30(–40) mm across, usually pale blue to mauve, sometimes pink, opening freely in warm weather. *Perianth segments* (7–)10–15(–20) mm long, 3–8 mm wide, concave, often shortly apiculate; *dorsal sepal* ovate, obtuse to subacute; *lateral sepals* lanceolate to ovate, slightly asymmetric, acute to obtuse; *petals* ovate, obtuse to subacute; *labellum* narrow-ovate to lanceolate, acute, often smaller than other segments. *Column* erect from the end of ovary, (4–)5–7 mm long, 2–4 mm wide,

Figure 1. a. *Thelymitra gregaria* Derrinallum, Vic. (photograph by J.A. Jeanes); **b.** *T. aggericola*, Arthur River, Tas. (photograph by J.A. Jeanes); **c.** *T. granitora*, Walpole, WA (photograph by J.A. Jeanes); **d.** *T. petrophila*, Brookton, WA (photograph by J.A. Jeanes); **e.** *T. fragrans*, Gibraltar Range N.P., NSW (photograph by J.A. Jeanes); **f.** *T. queenslandica*, Herberton Range, Qld (photograph by B. Gray)

white to pale blue or pale pink; *post-anther lobe* hooding the anther, 2.5–3.5 mm long, 1.4–2.5 mm wide, tubular, inflated, gently curved, brown to orange or reddish, apex entire or emarginate, sometimes yellow, distal margin undulate; *auxiliary lobes* often present as 2 tiny incurved spurs on the lower apical margin of the post-anther lobe; *lateral lobes* converging, 1–1.5 mm long, digitiform, porrect at base, curved upwards sharply at about the middle, each with a short toothbrush-like arrangement of white hairs along the upper ½ to ¾ of their length, the individual hairs 0.6–1 mm long. *Anther* inserted about mid-way along column, ovoid, 2.5–3.5 mm long, 1.5–2 mm wide, connective produced into a beak 0.3–0.8 mm long; *pollinarium* 1.8–2.5 mm long; *viscidium* more or less circular, 0.5–0.7 mm diam., often thrust forward; *pollinia* white with coherent pollen. *Stigma* situated at base of column, ovate-quadrate, 1.5–2.5 mm long, 1.2–2.2 mm wide, margins irregular. *Capsules* obovoid, 8–15 mm long, 4–7 mm wide, erect, ribbed. (Fig. 1d)

Figure 2. Distribution *af* **a.** *Thelymitra gregaria*; **b.** *T. aggericola*; **c.** *T. granitara*; **d.** *T. petraphila*; **e.** *T. fragrans*; **f.** *T. queenslandica*

***Selected specimens examined*: WESTERN AUSTRALIA.** Coolgardie District: False Duck Rock 1, 31.2 km SE of Hyden on road to Lake King, 28.ix.1991, *D.L. Jones 8008, C.H. Broers, M.A. Clements & B.E. Jones* (CANB 9609609); Roe District: Pallarup Rock, *c.* 20 km S of Lake King beside road to Ravensthorpe, 12.x.1988, *D.L. Jones 3013 & M.A. Clements* (CANB 8806676, BRI, NSW, MEL 2045546, AD 99541006 & PERTH); Roe District: *c.* 3.5 km N of Salmon Gums, beside road to Norseman, 24.ix.1991, *D.L. Jones 7887, C.H. Broers, M.A. Clements & B.E. Jones* (CANB 9609491); Coolgardie District: Dundas Rocks, *c.* 19.8 km S of Norseman, 2 km E of road to Esperance, 24.ix.1991, *D.L. Jones 7872, C.H. Broers, M.A. Clements & B.E. Jones* (CANB 9609479, PERTH 4563670); Coolgardie District: Grahams Rock *c.* 15 km E of Hyden, 1.x.2001, *J.A. Jeanes 1160 & S.A. Jeones* (MEL 2172925, MEL 2172927 & PERTH); Coolgardie District: The Humps *c.* 15 km NE of Hyden, 30.ix.2001, *J.A. Jeones 1159 & S.A. Jeones* (MEL 2172924, MEL 2172926 & PERTH); Roe District: Peak Charles, *c.* 100 km SW of Norseman, 11.x.1988, *D.L. Jones 3001 & M.A. Clements* (CANB 8806664); Coolgardie District: Keys Rocks, *c.* 21.5 km SW of Norseman Post Office, 1.x.2000, *B. Archer 1662* (MEL 2067962 & MEL 2067963).

***Distribution and habitat*:** Endemic to Western Australia. Found in drier inland areas throughout the Wheatbelt and Goldfields regions, and also extending into the Great Victorian Desert. Usually grows in shallow pockets of soil on granite rock outcrops, often in association with *Borya* species (Pincushions), but also occurs on laterite, ironstone and limestone. Sometimes found in tall mallee heathland and inland dune country in mulga scrub. Altitude: 200–600 m. (Fig. 2d)

***Conservation status*:** Widespread, often locally common and well conserved.

***Flowering period*:** Late August to October.

***Pollination biology*:** The easily spreading perianth, scented flowers, functional viscidium, coherent pollen and sporadic production of seed capsules would suggest that this species is entomophilous.

***Notes*:** *Thelymitra petrophila* has a proportionately very long leaf, compared with most other related species, the apex of which often (but not always) reaches the lowest flower and sometimes exceeds the entire inflorescence.

Natural hybrids with *Thelymitra campanulata* Lindl. have been observed.

***Etymology*:** Greek *petra*, rock; *phileo*, to love; in reference to the affinity this species has for rock outcrops.

5. *Thelymitra fragrans* D.L.Jones & M.A.Clem., *Austrobaileya* 2(5): 550–52, f. 2 C & D (1988)

***Type*: QUEENSLAND.** Moreton District: O'Reilly's property, Green Mountains, in clumps of *Dendrobium kingianum* on exposed escarpments, 14.ix.1987, *C. Harman s.n.* (holotype BRI!, isotypes AD!, BRI!, CANB 8804417, NSW 465647, PERTH 01553089).

Illustrations: Jones & Clements (1988) page 551, C & D; Bishop (1996) Plate 69; Jones (2006) page 229.

Glabrous terrestrial *herb*. *Tubers* ovoid to obovoid, 2–5 cm long, 1–2 cm wide, fleshy. *Leaf* linear-lanceolate to lanceolate, 10–30 cm long, 5–22 mm wide, usually flaccid, shallowly canaliculate or more or less flat, thin-textured, bright green, glossy, ribbed abaxially, sheathing at base, apex acute to acuminate. *Scape* 15–35 cm tall, 1.2–3.5 mm diam., slender, straight, green or purplish. *Sterile bracts* usually 2, rarely 1 or 3, linear to linear-lanceolate, 1.5–6 cm long, 4–10 mm wide, closely sheathing throughout, acute to acuminate, green or purplish. *Fertile bracts* lanceolate-acuminate to oblanceolate-acuminate, 4–21 mm long, 2.5–6 mm wide, sheathing the pedicels, green or purplish. *Pedicels* 6–18 mm long, slender. *Ovary* cylindric to narrow-obovoid, 5–12 mm long, 1–3 mm wide. *Flowers* 2–11, 21–36 mm across, usually pale blue, pink or mauve, rarely white, opening readily in warm weather, with a strong, spicy fragrance. *Perianth segments* 10–18 mm long, 4–8.5 mm wide, concave, often apiculate; *dorsal sepal* elliptic to ovate, obtuse to subacute; *lateral sepals* elliptic to ovate, often slightly asymmetric, obtuse to acute; *petals* ovate, obtuse to subacute; *labellum* obovate to oblanceolate, obtuse to subacute, often slightly smaller than other segments. *Column* erect from the end of ovary, 4.5–6 mm long, 2.2–3.5 mm wide, white to pale blue or pinkish; *post-anther lobe* hooding the anther, 2–3 mm long, 1.5–2.5 mm wide, tubular, inflated, brown, apex prominently bilobed with a notch 1–2 mm deep, lobes spreading, yellow or orange; *auxiliary lobes* absent; *lateral lobes* converging, 1–1.2 mm long, digitiform, fleshy, porrect, curving gently upwards, each with a short toothbrush-like arrangement of white hairs along the distal half, the individual hairs 1–1.5 mm long. *Anther* inserted near middle of column, ovoid, 2.3–3 mm long, 1.5–2.2 mm wide, connective produced into

a beak 0.4–0.6 mm long; *pollinarium* 1.9–2.4 mm long; *viscidium* more or less circular, 0.4–0.6 mm diam.; *pollinia* white with coherent pollen. *Stigma* situated near base of column, ovate-quadrate, 1.5–2.2 mm long, 1.5–2.7 mm wide, margins irregular. *Capsules* obovoid, 6–16 mm long, 4–6 mm wide, erect, ribbed. (Fig. 1e)

***Selected specimens examined*: QUEENSLAND.** Moreton district: Brisbane Forest Park, Northbrook Mt, 6.ix.1985, *R. Crane 69* (CANB B601136); Moreton district: Brisbane Forest Park, Northbrook Mt, 14.ix.198S, *R. Crane 74A* (CAN8 8601142); Darling Downs: Mt Huntley, western slopes, 4.x.1992, *P.I. Forster PIF11842, D. Halford & R. Reilly* (BRI 547134); Darling Downs: *c.* 1 km ENE of Gambubal Forest Station, E of Warwick, 6.x.1996, *A.R. Bean 10973* (8RI 641692); McPherson Ranges, x.1932, *T. Green s.n.* (MEL 651023); Moreton district: Mt 8allow National Park, 7.x.1995, *R. Crane 1464* (8RI 584003); Moreton district: Mount Ernest near Aratula, 11.ix.19B9, *G. Leiper s.n.* (BRI 44708S); Burleigh Heads, ix.1934, *C.P. Ledward s.n.* (NSW 19031B); Mt Ballow, ix.1949, *T.E. Hunt s.n.* (NSW 10467). **NEW SOUTH WALES.** 0.5 km from start of Perlite Drive, Whian Whian State Forest, 2B.ix.19B9, *A.D. Bishop J86/11-21* (NSW 2740S8); Rummerys Rd, 0.5 km N of Rocky Creek, Whian Whian State Forest, 3.x.1992, *A.D. Bishop J228/23-24* (NSW 4295B1); North Coast: Minyon Falls, 26 km NNE of Lismore, 2B.ix.1973, *I.R. Telford 3293* (CAN8 8202224); North Coast: 2 km N of Peach Mountain, NNE of Lismore, 29.ix.1973, *I.R. Telford 3319* (CANB 8202226); North Coast: Comboyne, 2B.ix.1966, *E. Todd s.n.* (CANB 8104452); North Coast: Coramba Mountain, *c.* 10 miles NW of Coffs Harbour, 9.ix.19S8, *L.W. Archer s.n.* (NSW 437714); Wilson River, 13.x.195B, *B.M. Borger s.n.* (NSW 190462); Orara, 16.ix.1959, *L.W. Archer s.n.* (NSW 190463); Gloucester 8ucketts, ix.1B97, *J.H. Maiden s.n.* (NSW 190467); South 8rother, Port Macquarie, 14.ix.1959, *B.M. Borger s.n.* (NSW 190471).

***Distribution and habitat*:** North-eastern New South Wales and south-eastern Queensland. Grows on rocky escarpments and rocky slopes in open forest, often near streams, usually in association with clumps of the lithophytic orchid *Thelychiton kingianus* (Bidw. ex Lindl.) M.A.Clem. & D.L.Jones. Altitude: 100–1200 m. (Fig. 2e)

***Conservation status*:** Widespread, often locally common and well conserved.

***Flowering period*:** August to October.

***Pollination biology*:** The large, freely opening, strongly scented flowers, functional viscidium, coherent pollen and sporadic capsule production would suggest that this species is entomophilous.

***Notes*:** *Thelymitra fragrans* can be distinguished from other members of the *T. nuda* complex by a combination of features including its very long, thin-textured leaf, usually two sterile bracts, moderately large scented flowers and deeply v-notched post-anther lobe on the column. The flowers apparently mimic those of co-flowering *T. kingianus* with which it usually grows.

6. *Thelymitra queenslandica* Jeanes, *sp. nov.*

***Type*: QUEENSLAND.** Cook District: c. 10 km W of Herberton towards Petford, 4.vii.2002, *D.L. Jones 18503* (holotype MEL 2173012; isotype CANB).

Illustrations: Dockrill (1992) vol. 1, page 171 (as *T. nuda*); Jones (2006) page 232.

Glabrous terrestrial *herb*. *Tubers* ovoid, 1–3 cm long, 5–15 mm wide, fleshy. *Leaf* linear to linear-lanceolate, 15–50 cm long, 5–15 mm wide, erect, canaliculate at base, thin-textured, dark green with a purplish base, ribbed abaxially, sheathing at base, apex acute. *Scape* 20–60 cm tall, 1.3–3.5 mm diam., slender, straight, green to purplish. *Sterile bracts* usually 3, sometimes 2 or 4, linear to linear-lanceolate, 1.5–11 cm long, 3–11 mm wide, closely sheathing, acute to acuminate, green to purplish. *Fertile bracts* ovate-acuminate to obovate-acuminate, 5–26 mm long, 3–8 mm wide, sheathing the pedicels, green to purplish. *Pedicels* 0–11 mm long, slender. *Ovary* cylindric to narrow-obovoid, 6–13 mm long, 1.5–3.5 mm wide. *Flowers* 4–15, (20–)25–35(–40) mm across, usually dark blue to purplish, occasionally lilac, pink or white, opening freely in warm weather. *Perianth segments* (10–)12–17(–20) mm long, 5–10 mm wide, concave, often shortly apiculate; *dorsal sepal* ovate, obtuse to subacute; *lateral sepals* lanceolate to ovate, slightly asymmetric, acute; *petals* ovate, obtuse to subacute; *labellum* elliptic to oblanceolate, acute, usually narrower than other segments. *Column* erect from the end of ovary, (5–)6–7 mm long, 3–4 mm wide, pale blue to pinkish; *post-anther lobe* hooding the anther, 3.5–4 mm long, 2–3.5 mm wide, tubular, inflated, gently curved through *c.* 90°, pale to dark brown, apex yellow, bilobed, lobes irregular, to *c.* 1.5 mm long; *auxiliary lobes* often present as 2 tiny incurved spurs on the lower apical margin of the post-anther lobe; *lateral lobes* converging, 1.2–1.7 mm long, digitiform, porrect at base, curved upwards, each with a more or less terminal mop-like arrangement of white or pink hairs along their upper

half, the individual hairs 1–1.5 mm long. *Anther* inserted about mid-way along column, ovoid, 2.5–3.5 mm long, 1.5–2.7 mm wide, connective produced into a beak 0.6–1 mm long; *pollinarium* 2–3 mm long; *viscidium* more or less circular, 0.5–0.8 mm diam.; *pollinia* white with coherent pollen. *Stigma* situated at base of column, ovate-quadrate, 2.2–3 mm long, 1.8–3 mm wide, margins irregular. *Capsules* obovoid, 10–20 mm long, 5–8 mm wide, erect, ribbed. (Fig. 1f)

***Selected specimens examined*: QUEENSLAND.** Herberton Range, viii.1996, *D.L. Jones ORG2620* (CANB 609329); Herberton Range, viii.1996, *D.L. Jones 14840* (CANB 611759); Cook District: Herberton Range, 26.viii.19B8, *L. Lowler 22* (CANB 8807166); Cook District: Herberton Range, north, 4.vii.1983, *D.L. Jones 11B7* (CANB 609381); Cook District: Herberton Range, towards Irvinebank, N side of road, 22.viii.1997, *D.L. Jones 15168* (CANB 61B158); Mt Bartle Frere, N slope of South Peak, 8.vi.1985, *A.M. Buchonon 7033* (HO 91561); Ravenshoe, 6.ix.1958, *K. Wodsworth, J.H. Wilkie, S.F. St Cloud & A.W. Dockrill s.n.* (QRS 44584); Cook District: Baal Gammon, Toy Creek, 3.vi.1997, *P.I. Forster PIF21217, R. Booth & R. Jensen* (BRI 655342); North Kennedy District: 17.4 km W of Ivy Teahouse, Paluma-Hidden Valley Road, 21.viii.1994, *J. Kemp 561H & A. Kutt* (BRI 632392); 8 km E of Hidden Valley on Paluma Road, 18.viii.19B4, *K. Hill 1156* (NSW 462475 & MEL 2172929); Cook District: Mt Lewis Road near Mt Spurgeon, 2B.1 km from Rex Highway, 20.viii.19B6, *P.H. Weston 776* (NSW 395239, MEL 2172923 & AD).

***Distribution and habitat*:** North Queensland between Cairns and Townsville. Grows in grassland, grassy/shrubby woodland and open forest, usually on well-drained stony skeletal brown loams or sandy loams. Altitude: 200–1200 m. (Fig. 2f)

***Conservation status*:** Poorly known, but probably reasonably widespread and conserved.

***Flowering period*:** Mostly from June to September.

***Pollination biology*:** The easily spreading perianth, functional viscidium, coherent pollen and sporadic production of seed capsules would suggest that this species is entomophilous.

***Notes*:** *Thelymitra queenslandica* is readily distinguished from all other members of the *T. nuda* complex by its northern distribution, early flowering period, long narrow leaf that often reaches the lowest flower and sometimes exceeds the entire inflorescence, usually three sterile bracts and the hair tufts on the lateral lobes that are concentrated along the distal half in a mop-like arrangement.

***Etymology*:** From the Australian State of Queensland where this species is apparently endemic.

7. *Thelymitra alcockiae* D.L.Jones ex Jeanes, *sp. nov.*

***Type*: SOUTH AUSTRALIA.** South-east Region: c. 20 km NE of Naracoorte, 20.x.1997, *K. Alcock DLJ15611* (holotype CANB 9908909; isotype AD).

Illustrations: Jeanes & Backhouse (2006) page 216, A & B (as *Thelymitra* sp. aff. *megcalyptra* 1); Bates (2011) pages 7 & 8.

Glabrous, somewhat glaucous terrestrial *herb*. *Tubers* ovoid, 1–2.5 cm long, 0.6–1 cm wide, fleshy. *Leaf* linear to linear-lanceolate, 8–25(–40) cm long, 5–10 mm wide, erect, canaliculate, green, grading to reddish purple towards base, ribbed abaxially, sheathing at base, apex acute to acuminate. *Scape* 10–40(–60) cm tall, 1–3.5 mm diam., slender to stout, straight, straw-coloured to purplish. *Sterile bracts* usually 2, sometimes 1, rarely 3, linear to linear-lanceolate, 1.5–7 cm long, 3–8 mm wide, closely sheathing, usually purplish, acute to acuminate. *Fertile bracts* ovate-acuminate to obovate-acuminate, 5–20 mm long, 3–7 mm wide, sheathing the pedicels, usually purplish. *Pedicels* 1–15 mm long, slender. *Ovary* cylindric to narrow-obovoid, 5–12 mm long, 1–3.5 mm wide. *Flowers* 2–8(–12), (15–)19–30 mm across, pink, mauve, pale blue to deep purplish blue, rarely white, sweetly scented, opening freely in warm weather. *Perianth segments* (8–)10–16 mm long, 4–8 mm wide, concave, apex acute to obtuse, often shortly apiculate; *dorsal sepal* ovate; *lateral sepals* ovate-lanceolate to ovate, slightly asymmetric; *petals* ovate; *labellum* lanceolate to ovate-lanceolate, slightly smaller than other segments. *Column* erect from the end of ovary, 4–6.5 mm long, 2.5–3.5 mm wide, pale blue to pinkish; *post-anther lobe* hooding the anther, 3–4 mm long, 2–2.5 mm wide, tubular, inflated, gently curved through c. 90°, brown, apex yellow, shallowly v-notched, margin of notch and apex irregularly undulate or toothed; *auxiliary lobes* often present as 2 tiny incurved spurs on the lower apical margin of the post-anther lobe; *lateral lobes* converging, 1–1.5 mm long, digitiform, porrect at base, bent upwards at c. 90° near the middle, each with a toothbrush-like arrangement of white hairs along

upper ½ to ¾ of their length, the individual hairs 0.5–1 mm long. *Anther* inserted about mid-way along column, ovoid, 2–3 mm long,. .1.5–2 mm wide, connective produced into a beak 0.3–0.5 mm long; *pollinarium* 2–2.5 mm long; *viscidium* more or less circular, c. 0.6 mm diam.; *pollinia* white with coherent pollen. *Stigma* situated at base of column, ovate-quadrate, 2–2.5 mm long, 2–2.5 mm wide, margins irregular. *Capsules* obovoid, 10–20 mm long, 4–7 mm wide, erect, ribbed. (Fig. 3a)

***Selected specimens examined*: SOUTH AUSTRALIA.** Northern Eyre Peninsula. Gawler Range; Yandinga Gorge, *c.* 37 km NNE of Minnipa, 26.ix.1969, *A.E. Orchord 2222* (AD 96947076); Northern Flinders Range. Wilpena Pound; *c.* 40 km NNE of Hawker, 11.ix.1957, *H. Goldsock B08* (AD 97631551); 90 Mile Desert, Mt Shaugh National Park, 2.x.1977, *C.R. Alcock 5655* (AD 98563933); Yorke Peninsula. Muloowurtie Conservation Reserve, 2.ix.1999, *D.L. Jones 16612 & M. Gorrott* (CANB 607203); Yorke Peninsula. 34 miles from Yorketown towards Stenhouse Bay, 18.x.1966, *M.E. Phillips* s.n. (CANB 039911); Yorke Peninsula. Innes National Park, 21.x.1976, *A. Robinson* s.n. (AD 9764B014); Lower Murray Mallee. MacDonald Reserve, Chaunceys Line, *c.* 20 km SW of Murray Bridge, 21.ix.1963, *J.B. Clelond* s.n. (AD 97311233); Northern Eyre Peninsula. Gawler Range c. 190 km W of Port Augusta, 13.ix.193B, *E.H. Ising* s.n. (AD 96935207); Eyre Peninsula. Hundred of Koppio, *c.* 30 km N of Port Lincoln, 18.ix.1964, *M.G. Clarke* s.n. (AD 98B39126); Eyre Peninsula. Hundred of Blesing, *c.* 8 km S of Bascombe Well Homestead, 5.x.1967, *N.N. Donner 2264* (AD 96817141); Kangaroo Island. 4.1 km SW of Penneshaw P.O., 13.xi.19B9, *P. Conty, S. Kinneor & B. Overton NPKI40527* (AD 99009001); 90 Mile Desert, environs of Comet Bore, 3.x.1977, *C.R. Alcock 5728* (AD 98563513). **VICTORIA.** Mallee. 15 km SW of Rainbow, just to NW of Lake Hindmarsh, 14.x.1970, *T.B. Muir 4844* (MEL 518813, MEL 2039680 & CANB 330129); Little Desert. By main N-S track 2.5 km S of Little Desert National Park and 27 km S of Kiata, 4.xi.1978, *T.B. Muir 6315* (MEL 565910); Sunset Country. 28 miles W of the road junction 14 miles N of Birthday Tank, 25.ix.1965, *R. Filson 7436* (MEL 114562); Sunset Country. Rock Hole Bore, ix.1963, *N. Wettenholl 12* (MEL 593647); Mallee. Sea Lake district, x.1912, *J.C. Goudie* s.n. (AD 97725201 & AD 97725193); Mallee. Wyperfeld, x.1965, *P. Hollond W28* (CANB 176787); Little Desert, between Booroopki and Kaniva, 2.xi.1971, *M.E. Phillips 420* (CANB 048586); Mallee. W side of hill, on E side of Calder Highway, between 317 & 31B mile posts, 25.viii.1951, *E. Romsoy* s.n. (MEL 1532669); Little Desert. Near fringe SE of Kaniva, x.1949, *A.C. 8eouglehole 18785* (MEL 1530150); Wimmera, 1B93, *W.E. Matthews* s.n. (MEL 114405 & MEL 114391); North-west Victoria, 1895, *M. Kentish* s.n. (MEL 1549678).

***Distribution and habitat*:** Found mostly in South Australia in the Eyre Peninsula, Yorke Peninsula, Flinders Ranges, Northern Lofty, Southern Lofty, Kangaroo Island, Murray Basin and South East Regions, but also extending to the Victorian Murray Mallee, Lowan Mallee and Wimmera Regions (Conn 1993). Grows in dry lowland areas, often in woodlands or mallee scrublands. Soils are usually well drained sands or sandy loams often over limestone. Altitude: 5–200 m. (Fig. 4a)

***Conservation status*:** Widespread, sometimes locally common and well conserved.

***Flowering period*:** Late August to October.

***Pollination biology*:** The scented flowers, readily spreading perianth, functional viscidium, coherent pollen and sporadic production of seed capsules would suggest that this species is entomophilous.

***Notes*:** The great variation displayed by *Thelymitra alcockiae* over its range, as well as its wide choice of habitats, is suggestive of there being more than one taxon involved. However, based on the preserved specimens, there would appear to be nearly as much variation within populations as between them. Segregate taxa cannot be isolated at this time as there is no apparent consistent correlation between morphology, plant size, flowering time and habitat over the range of the species.

***Etymology*:** Named after Kath Alcock (1925–), botanical artist and field naturalist with an extraordinary knowledge of the natural history of the Australian bush. Kath has assisted me considerably in my work on *Thelymitra*, and collected the type material of this species.

8. *Thelymitra imbricata* D.L.Jones & M.A.Clem., Contributions to Tasmanian Orchidology–8, *Austral. Orchid Res.* 3: 186–7 (1998)

Basionym: *Thelymitra nuda* R.Br. var. *grandiflora* Lindl., *Gen. sp. orchid. pl.* 520 (1840).

***Type*: TASMANIA.** Circular Head, xi.1837, *R. Gunn 940* (lectotype specimen 20b, K-L!, *fide* Clements 1989; isolectotype BM!, K!, FI!, P!).

Thelymitra megcalyptra sensu W.M. Curtis, *Student's Fl. Tasmania* 4A 43 (1979), *non* Fitzg.

Illustrations: Jones *et al.* (1999) page 273; Jones (2006) page 230.

Glabrous terrestrial *herb*. *Tubers* ovoid, 1–3 cm long, 5–13 mm wide, fleshy. *Leaf* linear to linear-lanceolate, 15–30 cm long, 5–18 mm wide, erect, canaliculate, fleshy, light green with a purplish base, ribbed abaxially, sheathing at base, apex acute. *Scape* 15–60 cm tall, 1.5–3 mm diam., slender, straight, light green, straw-coloured or purplish. *Sterile bracts* usually 2, linear to linear-lanceolate, 2.5–8 cm long, 4–8 mm wide, closely sheathing, acute to acuminate, green or purplish. *Fertile bracts* ovate-acuminate to obovate-acuminate, 5–20 mm long, 3–7 mm wide, sheathing the pedicel, green or purplish. *Pedicels* 2–12 mm long, stout to slender. *Ovary* cylindric to narrow-obovoid, 4–10 mm long, 1.5–4 mm wide. *Flowers* 3–15, (19–)25–35 mm across, usually pale purplish blue, opening freely in warm weather. *Perianth segments* (8–)12–20 mm long, 5–10 mm wide, concave, imbricate in open flowers, apex acute to obtuse, often shortly apiculate; *dorsal sepal* ovate; *lateral sepals* lanceolate to ovate, slightly asymmetric; *petals* ovate; *labellum* elliptic to oblanceolate, often stalked, usually narrower than other segments. *Column* erect from the end of ovary, 5–7 mm long, 2.5–3.5 mm wide, pale blue to pinkish; *post-anther lobe* hooding the anther, 3–3.5 mm long, 1.8–2.2 mm wide, tubular, inflated, gently curved, brown or brownish orange with a narrow blue collar, apex v-notched, yellow, lobes toothed; *auxiliary lobes* often present as 2 tiny incurved spurs on the lower apical margin of the post-anther lobe; *lateral lobes* converging, 1.5–2 mm long, digitiform, porrect at base, curved sharply upwards, each with a dense toothbrush-like tuft of white hairs, the individual hairs 0.7–1 mm long. *Anther* inserted towards apex of column, ovoid, 2.5–3.2 mm long, 1.5–2 mm wide, the connective produced into a beak 0.5–0.6 mm long; *pollinarium* 2–2.6 mm long; *viscidium* more or less circular, c. 0.5 mm diam.; *pollinia* white with coherent pollen. *Stigma* situated at base of column, ovate-quadrate, c. 2.5 mm long, c. 2 mm wide, margins irregular. *Capsules* obovoid, 10–15 mm long, 4.5–6 mm wide, erect, ribbed. (Fig. 3b)

***Selected specimens examined*: TASMANIA.** Howrah Hills, 26.x.1998, *D. Randall s.n.* (HO 500013); Conara, Midland Highway near church, 18.xi.1998, *H. & A. Wapstra s.n.* (HO 500102); Conara, track to old church, 18.xi.1998, *J.E. Wapstra ORG1945 & A. Wapstra* (CAN8 610454); Conara Junction, 18.xi.1998, *J.E. Wapstra ORG1830* (CAN8 610402); Conara, just north of railway crossing, 27.xi.1996, *H. & A. Wapstra s.n.* (HO 329537); Campbell Town Golf Course, 28.xi.1995, *H. & A. Wapstra s.n.* (HO 500107); Campbell Town Golf Course, 21.xi.1995, *H. Wapstra DLJ14685* (CAN8 9609758); Campbell Town Golf Course, 5.xi.1998, *D.L. Jones 16181 & M. Garratt* (CAN8 605821); Conara, Midland Highway, 27.xi.1996, *J.E. Wapstra ORG460* (CAN8 610405 & HO 500101); Maranoa Heights, Kingston, 11.xi.1996, *J.E. Wapstra ORG441* (CAN8 610404); Conara, 14.xi.1999, *H. & A. Wapstra JAJ692* (MEL 2172980); Campbell Town Golf Course, 8.xi.2000, *H. Wapstra JAJ945* (MEL 2087452 & MEL 2089307).

***Distribution and habitat*:** Northern and eastern Tasmania from Circular Head to near Hobart, with most recent collections coming from the Midlands Region in the vicinity of Campbell Town. Grows in heathy open forest, scrubland or grassland on well-drained sand and sandy loams. Altitude: 0–200 m. (Fig. 4b)

***Conservation status*:** Not recorded for any biological reserves and poorly known overall. Recommend 3K by criteria of Briggs and Leigh (1996) and Data Deficient (DD) by criteria of IUCN (2011).

***Flowering period*:** Late October to early December.

***Pollination biology*:** The large, freely opening flowers and sporadic production of seed capsules would suggest that this species is most likely entomophilous.

***Notes*:** *Thelymitra imbricata* has been confused with *T. nuda* from which it can be distinguished by its generally stockier appearance, often longer, broader leaf and the usually larger flowers with broader, more overlapping perianth segments.

9. *Thelymitra paludosa* Jeanes, *sp. nov.*

***Type*: WESTERN AUSTRALIA.** Eyre District: Mt Merivale, 20 km E of Esperance, 7.xi.1995, *B. Archer 178* (holotype MEL 2032843; isotypes MEL 2032844, PERTH 4433432)

Illustrations: Hoffman & Brown (1998) page 267 (as *Thelymitra* aff. *holmesii*); Brown *et al.* (2008) page 331, A; Hoffman & Brown (2011) page 323.

Glabrous terrestrial *herb*. *Tubers* ovoid, 1–3 cm long, 5–15 mm wide, fleshy. *Leaf* linear, 14–30(–50) cm long, 5–10(–15) mm wide, erect, canaliculate, leathery, dark green with a purplish base, ribbed abaxially, sheathing at base, apex acute. *Scape* 20–50(–90) cm tall, 1.5–5 mm diam., straight, green to purplish. *Sterile bracts* usually 2 or 3, rarely 1, linear to linear-lanceolate, 2–10 cm long, 4–12 mm wide, lower bracts closely sheathing throughout, acuminate, when 3 bracts present upper

one often more or less free with the base only half encircling the inflorescence, green to purplish. *Fertile bracts* ovate-acuminate to obovate-acuminate, 5–32 mm long, 3–9 mm wide, sheathing the pedicels, green to purplish. *Pedicels* 0.5–18 mm long, slender. *Ovary* cylindric to narrow-obovoid, 4–12 mm long, 1–4 mm wide. *Flowers* 2–10(–18), 18–30(–45) mm across, blue to violet, occasionally pink or white, often strongly scented, opening freely in warm weather. *Perianth segments* 8–18(–20) mm long, 4–10 mm wide, concave, sometimes stalked to spathulate, often shortly apiculate; *dorsal sepal* ovate, acute to obtuse; *lateral sepals* lanceolate to ovate, slightly asymmetric, acute; *petals* ovate, acute to obtuse; *labellum* elliptic to oblanceolate, usually slightly smaller than other segments, acute. *Column* erect from the end of ovary, (5–)6–8.5 mm long, (2–)3–5 mm wide, pale blue to pinkish; *post-anther lobe* hooding the anther, 3.5–4.5 mm long, 1.5–3 mm wide, tubular, hardly inflated, gently curved through *c.* 90°, dark brown to almost black, apex dorsally compressed, yellow, emarginate to shallowly v-notched, distal margin irregularly toothed; *auxiliary lobes* often present as 2 tiny incurved spurs on the lower apical margin of the post-anther lobe; *lateral lobes* converging, 1–2 mm long, digitiform, porrect at base, bent upwards at *c.* 90° near the middle, each with a toothbrush-like arrangement of white hairs along the upper ½ to ¾ of their length, the individual hairs 0.6–1.2 mm long. *Anther* inserted about mid-way along column, ovoid, 2.3–3.3 mm long, 1.5–2.5 mm wide, connective produced into a beak 0.3–0.9 mm long; *pollinarium* 1.7–2.6 mm long; *viscidium* more or less circular, 0.4–0.8 mm diam.; *pollinia* white with coherent pollen. *Stigma* situated at base of column, ovate-quadrate, 2–3 mm long, 1.8–2.5 mm wide, margins irregular. *Capsules* obovoid, 10–20 mm long, 5–8 mm wide, erect, ribbed. (Fig. 3c)

***Selected specimens examined*: WESTERN AUSTRALIA.** Walpole Nornalup National Park, 13 km WSW of Walpole, 30.xi.1988, *G. Wardell-Johnson W123* (PERTH 2661160 & PERTH 2661179); Darling District: Reserve 1167, Site 6, Map 2031 Bunbury, Dardarnup, 20.x.1997, *S. Fisher 137* (PERTH 5001501); 12 km SW of Pemberton, 8.xii.1988, *A.R. Annels 511* (PERTH 2661195); Pingerup Road, 2.5 km NE of Chesapeake Road junction, near Broke Inlet, 16.xi.1991, *N. Gibson & M. Lyons 1138* (PERTH 3133478); Links Road, SE of Mt Barker, 16.xi.1993, *A.R. Annels ARA4171* (PERTH 4572289); SW of Manjimup near Jardee and Deanmill, 15.xi.1968, *G.S. McCutcheon 122* (PERTH 306452); Walpole Nornalup National Park, Conspicuous Beach, 9.xi.1988, *A.R. Annels 447* (PERTH 2661209); Ambergate Reserve, 9 km S of Busselton, 7.xi.1992, *B.J. Keighery & N. Gibson 789* (PERTH 4496469); 12 km ENE of Denmark, E of Sunny Glen Road, 5.xii.1993, *A.R. Annels ARA4327* (PERTH 4587499); Mount Barker–Denmark Rd, *c.* 1 km NE of Harvey Rd, 19.x.2000, *J.A. Jeanes 852* (MEL 2087466, MEL 2087467 & PERTH); North Walpole Rd, near Walpole, 4.xii.2001, *W. Jackson JAJ1127* (MEL 2172996); Mt Chudalup, lower slope of dome adjacent to boardwalk, 1.xi.1994, *A.R. Annels & R.W. Hearn ARA4773* (PERTH 4125843).

***Distribution and habitat*:** Western Australia. Found in higher rainfall near-coastal regions of the south, from near Bunbury to just east of Esperance. Usually grows around the margins of winter-wet swamps. Altitude: 10–100 m. (Fig. 4c)

***Conservation status*:** Widespread, sometimes locally common and well conserved.

***Flowering period*:** Mid-October to December.

***Pollination biology*:** The easily spreading perianth, scented flowers, functional viscidium, coherent pollen and sporadic production of seed capsules would suggest that this species is entomophilous.

***Notes*:** *Thelymitra paludosa* is closely related to, and often confused with, *T. macrophylla*, but the latter usually flowers earlier (although there is some overlap), grows in drier habitats, has a more robust habit, a generally broader leaf and more, somewhat larger flowers. Earlier flowering (September to October) plants of similar appearance to *T. paludosa* from swamps between Perth and Bunbury (Hoffman & Brown 2011) need further study. Similar looking sympatric plants from drier, well-drained sites that flower from late October to December also need further study (Andrew Brown pers. comm. 2012).

***Etymology*:** Latin *paludosa*, boggy, marshy; a reference to the preferred habitat of this species.

10. *Thelymitra nuda* R.Br., *Prodr.* 314 (1810)

***Type*: TASMANIA.** *In pratis dipritis prope Western Arm Port Dalrymple* (Tasmania. Near the Western Arm of Port Dalrymple), 5.i.1804, *R. Brown s.n.* (lectotype specimen (a) BM!, *fide* Clements 1989; isolectotypes BM!, E!, FI, P). *Syntype*: Port Dalrymple, 1805, *R. Brown s.n.* (BM!, K!, AD!)

Thelymitra versicolor Lindl., *Gen. sp. orchid pl.* 520 (1840). *Type*: Tasmania, Circular Head, xii.1837, *R. Gunn 943* (holotype P!); *Syntype*: Tasmania, *R. Gunn 943* (BM!).

Thelymitra angustifolia sensu Hook.f., *Fl. Tasman.* 2: 5 (1858), *non* R.Br. (1810).

Thelymitra grandis F.Muell. ex Benth., *Fl. Austral.* 6: 319 (1873), *nom. nud.*

Illustrations: Backhouse & Jeanes (1995) page 356 (as *T. pauciflora*); Jones *et al.* (1999) page 281; Jeanes & Backhouse (2006) page 206, A & B; Jones (2006) page 231.

Glabrous terrestrial *herb*. *Tubers* ovoid, 1–3 cm long, 5–12 mm wide, fleshy. *Leaf* linear to linear-lanceolate, 10–25 cm long, 5–12 mm wide, erect, fleshy, canaliculate, dark green with a purplish base, ribbed abaxially, sheathing at base, apex acute to acuminate. *Scape* 15–50 cm tall, 1.2–3.5 mm diam., slender to moderately stout, straight, green to purplish. *Sterile bracts* usually 2, rarely 1 or 3, linear to linear-lanceolate, 1.4–7 cm long, 3–9 mm

Figure 3. a. *Thelymitra alcockiae*, Tintinara, SA (photograph by J.A. Jeanes); **b.** *T. imbricata*, Campbelltown, Tas. (photograph by J.A. Jeanes); **c.** *T. paludosa*, Denmark, WA (photograph by A.P. Brown); **d.** *T. nuda*, Eaglehawk Neck, Tas. (photograph by J.A. Jeanes); **e.** *T. graminea*, Darling Ranges, WA (photograph by A.P. Brown); **f.** *T. glaucophylla*, Spring Gully C.P., SA (photograph by J.A. Jeanes)

wide, closely sheathing, acute to acuminate, green to purplish. *Fertile bracts* ovate-acuminate to obovate-acuminate, 4–20(–25) mm long, 3–5 mm wide, green to purplish, sheathing the pedicels. *Pedicels* 1–17 mm long, slender. *Ovary* narrow-obovoid, 6–13 mm long, 1–3 mm wide. *Flowers* (1–)3–8(–12), (15–)20–30(–35) mm across, usually dark blue to purplish, rarely pink or white, opening readily on warm to hot days. *Perianth segments* (8–)11–15(–18) mm long, 3–6 mm wide, concave, not overlapping greatly in open flowers, often shortly apiculate; *dorsal sepal* ovate-lanceolate to ovate, obtuse to subacute; *lateral sepals* ovate-lanceolate to ovate, often slightly asymmetric, acute; *petals* ovate to obovate, obtuse to subacute; *labellum* elliptic to lanceolate, often smaller than other segments, acute. *Column* erect from the end of ovary, 5–6.5 mm long, 2.5–3.5 mm wide, pale purplish or pale pink; *post-anther lobe* hooding the anther, 3–4 mm long, 1.5–2 mm wide,

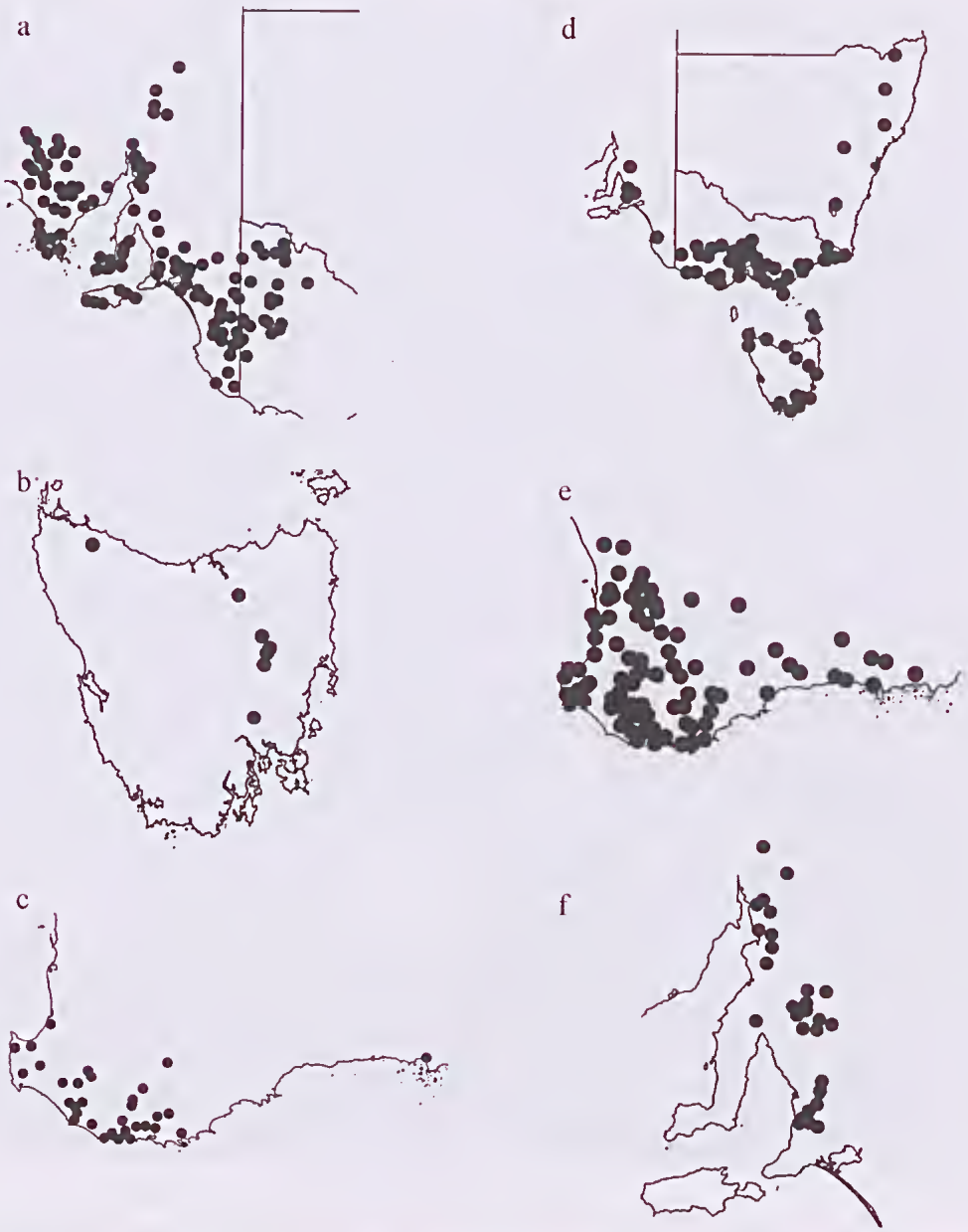

Figure 4. Distribution of **a.** *Thelymitra alcockiae*; **b.** *T. imbricata*; **c.** *T. paludosa*; **d.** *T. nuda*; **e.** *T. graminea*; **f.** *T. glaucophylla*

tubular, inflated, gently curved through c. 90°, usually dark brown or blackish, apex yellow, emarginate or shallowly v-notched, the lobes to c. 1 mm long; *auxiliary lobes* often present as 2 tiny incurved spurs on the lower apical margin of the post-anther lobe; *lateral lobes* converging, 1.2–2 mm long, digitiform, porrect at base, bent sharply upwards near the middle at c. 90°, each with a toothbrush-like arrangement of white hairs along almost their entire length, the individual hairs 0.5–1 mm long. *Anther* inserted near centre of column, ovoid, 2.5–3.5 mm long, 1.5–2 mm wide, the connective produced into an apical beak 0.4–0.7 mm long; *pollinarium* 2–3 mm long; *viscidium* more or less circular, c. 0.5 mm diam.; *pollinia* white with coherent pollen. *Stigma* situated at base of column, ovate-quadrate, 2–2.5 mm long, 1.5–2 mm wide, margins irregular. *Capsules* obovoid, 8–16 mm long, 4–8 mm wide, erect, ribbed. (Fig. 3d)

***Selected specimens examined*: SOUTH AUSTRALIA.** Southern Lofty Region: Teatree Gully c. 15 km NE of Adelaide, 27.ix.1913, *?R.S. Rogers s.n.* (AD 98003218); Goolwa Scrub, 30.x.1894, *?Tate s.n.* (AD 9751B179); Mount Lofty Range. Echunga, ix., *J. Ferries s.n.* (AD 96750984); Southern Lofty Region: Aldgate, 15.x.1911, *R.S. Rogers 4972* (AD 97725220); Southern Lofty Region: Belair Recreation Park, SE of Adelaide, 1.x.1909, *R.S. Rogers 4981* (AD 97725219); Pine oval, x.1944, *R.A. Perry s.n.* (CANB 18330); Mt Lofty Range. Belair National Park, 22.x.1910, *E.H. Ising s.n.* (AD 966031489); Willunga via Blackwood, x.1906, *E. Ashby s.n.* (MEL 114492 & MEL 20395B6); Clare Hills, 8.x.1957, *B.B. Lowery s.n.* (QRS 0445B5); Mt Lofty Range. Black Hill, *J. Ferries s.n.* (AD 96750983); Southern Lofty Region: Black Hill Native Flora Park; near Athelstone, c. 10 km ENE of Adelaide, 6.xi.1980, *K. Clipstone S2* (AD 98046031); Port Elliot, x.1896, *Tate 41* (AD 96945236A). **NEW SOUTH WALES.** Albury, 15.x.1950, *E.J. McBarron s.n.* (NSW 156398); Tenterfield (MEL 114484); On hill above falls, Gloucester River, Gloucester Tops, 26.x.1963, *R. Filson S540* (MEL 646914); Armidale, *Perrott s.n.* (MEL 114495); Central Tablelands: 56 km N of Taralgo on road to Oberon, 2.xii.1984, *M.A. Clements 3596* (CANB 84117B7); Paramatta, *W. Woolls s.n.* (MEL 114491); 20 km E of Guyra, 21.xi.1987, *R.J. Bates 12771* (AD 98746535); Northern Tablelands: Lot 90, Invergowrie, 28.x.1990, *S. McIntyre s.n.* (NSW 415781); Central Tablelands: 7 km from Binda along road to Crookwell, 24.x.1998, *R.W. Purdie 4660* (CANB 9810236); Gloucester Tops, W of Gloucester, 2.xi.1968, *B.G. Briggs 2464* (NSW 124945). **AUSTRALIAN CAPITAL TERRITORY.** Western slopes of Mt Taylor, 13.xi.1991, *D.L. Jones 8507, B.E. Jones & S.R. Jones* (CANB 9803903). **VICTORIA.** Glenelg River, *C. Walter s.n.* (MEL 22164B); South-west. Richardsons River, S of Casterton-Penola Rd, 27.x.1963, *A.H. Corrick s.n.* (MEL 665163); Shepherds Gap, Grampians, xi.1920, *J.W. Audas s.n.* (MEL 1549676); Bannockburn, x.1938, *W.H. Nicholls s.n.* (MEL 650294 & MEL 650377); Steiglitz heathlands, 27.ix.1969, *M. Quick s.n.* (MEL 518814); Blue Range Creek, x.1906, *C.S. Sutton s.n.* (AD 97725185); 1 km SW of Fernbank, 4.x.1984, *A.C. Beauglehole 77751* (MEL 670969); Boronia, x.1929, *A.B. Braine s.n.* (MEL 625596 & MEL 2039604); Hurstbridge, x.1930, *W.H. Nicholls s.n.* (MEL 625587); Creswick, x.1930, *J.H. Willis s.n.* (MEL 577252); Bay of Islands Coastal Park, Flaxmans Hill area c. 200 m from coastal cliffs, 30.xi.2000, *A. Pritchard JAJ800* (MEL 2172974). **TASMANIA.** Mt Direction, 6.xii.1841, *R.C. Gunn s.n.* (HO 99285); Bruny Island, 4 km E of Alonnah along Bruny Island Main Road, 22.xi.2000, *H. Wapstra JAJ784, A. Wapstra & L. Rubenach* (MEL 2087444 & MEL 2089316); Newtown, 31.x.1990, *D.L. Jones 6B65 & C.H. Broers* (CANB 9016335); Howrah, 3.xi.1992, *D. Randall DLJ10610* (CANB 9702476); Ridgeway Park, near Mt Wellington, 16.xii.1992, *M. Wapstra DLJ11008 & L. Yeates* (CANB 605294); Risdon Hill, 8.xi.1960, *M.E. Phillips s.n.* (CANB 14372); St Marys, xi.1929, *E. Rees s.n.* (HO 99288 & HO 99292); Domain, Hobart, 28.x.1937, *H.D. Gordon s.n.* (HO 99295); Barossa Road, Glenorchy, 31.x.1931, *F.H. Long 971* (HO 9929B); Lindisfarne, 3.xi.1934, *E.W. Little s.n.* (HO 411697); Kingston Beach, 17.xi.1940, *Mrs O. Rodway s.n.* (AD 97913267); Pirates Rd, Tasman Peninsula, 25.xi.2001, *H. & A. Wapstra JAJ1123* (MEL 2172928 & MEL 2172930).

***Distribution and habitat*:** South Australia, New South Wales, Australian Capital Territory, Victoria and Tasmania. Found mostly in more mesic near-coastal forests and heathlands on sandy, gravelly or clay loam soils. Altitude: 5–1000 m. (Fig. 4d)

***Conservation status*:** Widespread, sometimes locally common and well conserved.

***Flowering period*:** October to December.

***Pollination biology*:** The easily spreading perianth, functional viscidium, coherent pollen and sporadic production of seed capsules would suggest that this species is entomophilous.

***Typification*:** The type sheet contains five specimens of fairly uniform appearance with two labels showing different dates but similar origins. The two left-hand specimens appear to be part of the same collection, and Clements (1989) selected specimen (a), the more intact of the two, as the lectotype, the other (b) becoming an isolectotype. The three specimens on the right (c, d & e) are probably best regarded as syntypes.

***Brown's Latin description* (Brown 1810):** T. nuda, *cucullo perianthio patulo dimidio breviore: laciniis extimis penicillatis: intermediâ dorso nudo emarginatâ lobulis*

rotundatis integris, spicâ multiflorâ. (Hood shorter than half the widely spread perianth: side lobes penicillate: post-anther lobe naked, emarginate, lobules rounded, entire, spike many-flowered.)

***Notes*:** Plants consistent with Brown's description of *Thelymitra nudo* and with the specimens on the type sheet still occur near the type locality in northern Tasmania, and have been collected recently and studied. This taxon appears to be relatively common and widespread, at least through much of south-eastern Australia.

Hybridises with *T. antennifera* to produce *T. ×macmillanii* and with *Thelymitro ixioides* Sw. and *Thelymitra ozurea* R.S. Rogers (Jones 2006).

11. *Thelymitra graminea* Lindl. in *Edwards's Bot. Reg.* 1–23: Sketch Veg. Swan R., app. 49 (216) (1839–40)

***Type*: WESTERN AUSTRALIA.** Swan River, 1839, *J. Drummond s.n.* (holotype K-L!).

Illustrations: Brown *et al.* (2008) page 331, B; Hoffman & Brown (2011) page 321.

Glabrous terrestrial *herb*. *Tubers* ovoid, 1–3 cm long, 7–15 mm wide, fleshy. *Leaf* linear, 7–25 cm long, 5–10(–12) mm wide, erect, canaliculate, leathery, dark green with a purplish base, ribbed abaxially, sheathing at base, apex acute. *Scope* 20–55 cm tall, 1.5–3.5 mm diam., usually slender, straight, green to purplish. *Sterile bracts* usually 2, sometimes 3, linear to linear-lanceolate, 2–6(–10) cm long, 4–9 mm wide, closely sheathing, acute to acuminate, green to purplish. *Fertile bracts* ovate-acuminate to obovate-acuminate, 5–20 mm long, 3–7 mm wide, sheathing the pedicels, green to purplish. *Pedicels* 1–12 mm long, slender. *Ovary* cylindric to narrow-obovoid, 5–10 mm long, 1–3.5 mm wide. *Flowers* 1–8(–14), 25–30 mm across, usually dark blue to purplish, often strongly scented, opening freely in warm weather. *Perianth segments* 10–17 mm long, 4–10 mm wide, concave, apex acute to obtuse, often shortly apiculate; *dorsal sepal* ovate; *lateral sepals* lanceolate to ovate, slightly asymmetric; *petals* ovate; *labellum* elliptic to oblanceolate, usually slightly smaller than other segments. *Column* erect from the end of ovary, 6–7.5 mm long, 3–4 mm wide, pale blue to pinkish; *post-anther lobe* hooding the anther, 3.5–4 mm long, 1.4–2.2 mm wide, tubular, hardly inflated, gently curved through *c.* 90°, dark brown to almost black, apex yellow, entire to shallowly emarginate, distal margin more or less smooth; *auxiliory lobes* often present as 2 tiny incurved spurs on the lower apical margin of the post-anther lobe; *lateral lobes* converging, 1.5–2 mm long, digitiform, porrect at base, bent upwards at c. 90° near the middle, each with a toothbrush-like arrangement of white hairs along the upper ½ to ¾ of their length, the individual hairs 0.7–1.1 mm long. *Anther* inserted about mid-way along column, ovoid, 2.5–3.5 mm long, 1.5–2.5 mm wide, connective produced into a beak 0.4–0.6 mm long; *pollinorium* 2–3 mm long; *viscidium* more or less circular, 0.3–0.6 mm diam.; *pollinio* white with coherent pollen. *Stigma* situated at base of column, ovate-quadrate, 2–3 mm long, 1.5–2.5 mm wide, margins irregular. *Capsules* obovoid, 10–15 mm long, 5–7 mm wide, erect, ribbed. (Fig. 3e)

***Selected specimens examined*: WESTERN AUSTRALIA.** Brookton Hwy near intersection of Darkan Road, 12.x.2000, *J.A. Jeones 834* (MEL 2093610, MEL 2093611 & PERTH); Near corner of *B*rookton Hwy and Lupton Road, 12.x.2000, *J.A. Jeones 832* (MEL 2093608, MEL 2093609 & PERTH); Dryandra State Forest, Koomal Rd *c.* 1.5 km E of York–Williams Rd, 17.x.2000, *J.A. Jeones 848* (MEL 2087478, MEL 2087479 & PERTH); Rock opposite Tindale Rd and adjacent to South Coast Highway. Mehinup Nature Reserve, *c.* 31 km E of Walpole, 19.x.2000, *J.A. Jeanes 854 & W. Jackson* (MEL 2087470, MEL 2087471 & PERTH); Toolbrunup Rd at intersection of Aylmore Rd; *c.* 14 km ESE of Tambellup, 17.x.2000, *J.A. Jeanes 850* (MEL 2093572, MEL 2093573 & PERTH); Darling District: 17.6 km N of Kojonup, 8.x.1991, *D.L. Jones 8243* (CAN 609382); Brookton area. Moorumbine Rd, *c.* 100 m SE of Schultz Rd, behind quarry, 15.x.2000, *J.A. Jeones 844, C. French & H. Beyrle* (MEL 2093578, MEL 2093579 & PERTH); Corner of Qualen Rd and Kitters Rd, SW of York, 14.x.2000, *J.A. Jeones 839, C. French & H. Beyrle* (MEL 2087465, MEL 2089294); Avon District: 29 km W of *B*rookton beside *B*rookton Hwy, 7.x.1991, *D.L. Jones 8202* (CAN 609383); *B*lue Rock near Jarrahdale, 14.x.2001, *C.J. French 3216* (MEL 2172970); Darling District: 20 km SE of Moodiarrup, 23.ix.1985, *D.L. Jones 1940, B.E. Jones & A.P. Brown* (CAN 8506425); Darling District: Crooked *B*rook Rd, 2.8 km W of Ferguson Rd, 7 km ESE of Dardanup, 31.x.1998, *P.H. Weston 2197 & 2198* (NSW 432775 & NSW 432776).

***Distribution and habitat*:** Western Australia between about Gingin and Esperance. Found mostly in higher rainfall near-coastal regions and in the ranges and hill country, but extending inland to the edges of the

wheatbelt. Preferred habitats include open forest, woodlands, heathy woodlands and mallee scrubs on well-drained sandy or lateritic soils. Altitude: 10–500 m. (Fig. 4e)

***Conservation status*:** Widespread, often locally common and well conserved.

***Flowering period*:** September to November.

***Pollination biology*:** The easily spreading perianth, scented flowers, functional viscidium, coherent pollen and sporadic production of seed capsules suggest that this species is entomophilous.

***Typification*:** The type sheet is a mixed collection containing a single specimen (the lectotype) of *Thelymitra campanulata* Lindl. on the right, and three specimens of *T. graminea* on the left, the latter of fairly uniform appearance and apparently from a single collection. The specimens are 33–36 cm tall, have a relatively narrow leaf (the upper part of the leaf on all three specimens is missing) and 3–6 flowers with perianth segments about 10 mm long.

***Lindley's Latin description* (Lindley 1839–40):** Thelymitra graminea; *folio radicali lineari, racemo secundo multifloro, floribus purpureis, cuculli laciniis lateralibus stuposis unguiculatis intermedia fornicata integerrima glaberrima*. (Leaf radical linear, raceme one-sided multi-flowered, flowers purple, hood with lateral flaps covered with matted hairs clawed mid-lobe arched quite entire and glabrous).

***Notes*:** A somewhat stylised drawing by Lindley of a semi-frontal view of a column is on the lower left-hand side of the sheet containing the holotype. This shows the post-anther lobe to be entire and the lateral lobes to be glabrous towards the base and with an elongate, toothbrush-like arrangement of hairs along the upper part. Lindley (1840) notes "A very slender species near *T. nuda*, from which it differs in the form of the middle lobe of the cucullus (post-anther lobe)". From Drummond's journal it would appear that he collected the type material of *T. graminea* somewhere between Perth and his farm at Toodyay (A. Brown pers. comm.). Plants consistent with Lindley's description, notes and with the type collection of *T. graminea* still occur in the ranges to the east of Perth, and specimens have been collected recently and studied. It is apparent that this taxon remains poorly known today due to the presence of several superficially similar taxa, both in Western Australia and in the eastern states.

12. *Thelymitra glaucophylla* R.J.Bates ex Jeanes, ***sp. nov.***

***Type*: SOUTH AUSTRALIA.** Northern Lofty Region: Leighton Road, W of Sevenhill, 18.xi.2001, *R.J. Bates 60334* (holotype AD 187235, isotypes MEL 2172094, MEL 2172095, AD 138701, CANB).

Illustration: Bates (2011) pages 43 & 44.

Glabrous, glaucous, terrestrial *herb*. *Tubers* ovoid, 1–2.5 cm long, 6–12 mm wide, fleshy. *Leaf* linear-lanceolate to lanceolate, 10–50 cm long, 8–20 mm wide, erect, canaliculate, fleshy, pale green with a whitish bloom and a purplish base, often senescent at anthesis, ribbed abaxially, sheathing at base, apex acute to acuminate. *Scape* 25–80 cm tall, 1.5–5 mm diam., slender to stout, straight, glaucous green to purplish. *Sterile bracts* usually 2, rarely 3, linear to linear-lanceolate, 2.5–10 cm long, 4–12 mm wide, closely sheathing, glaucous green, often purplish towards apex, acuminate to subulate. *Fertile bracts* ovate-acuminate to obovate-acuminate, 5–32 mm long, 3–9 mm wide, sheathing the pedicels, glaucous green to purplish. *Pedicels* 1–15(–23) mm long, slender. *Ovary* cylindric to narrow-obovoid, 5–17 mm long, 1–4 mm wide, glaucous. *Flowers* 3–15, (20–)30–50 mm across, usually pale blue, mauve or white, strongly sweet-scented, opening freely in warm weather. *Perianth segments* (10–)15–25 mm long, 4–13 mm wide, concave, somewhat stalked to spathulate, apex acute to obtuse, often shortly apiculate; sepals glaucous on outer surface; *dorsal sepal* ovate; *lateral sepals* lanceolate to ovate, slightly asymmetric; *petals* ovate; *labellum* elliptic to oblanceolate, hardly smaller than other segments. *Column* erect from the end of ovary, 5.5–7.5 mm long, 3–4.5 mm wide, pale blue to pinkish; *post-anther lobe* hooding the anther, 3.5–4.5 mm long, 2.5–3.7 mm wide, tubular, very inflated, somewhat dorsally compressed, gently curved through c. 90°, greyish brown, surface often ruminate, apex yellow, toothed, bilobed, lobes irregular, to c. 1.6 mm long, inner margins toothed; *auxiliary lobes* often present as 2 tiny incurved spurs on the lower apical margin of the post-anther lobe; *lateral lobes* converging, 1–2 mm long, digitiform, porrect at base, curved upwards gradually throughout or at c. 90° near the middle, each with a toothbrush-like arrangement of white or creamy yellow hairs along most of their length, the individual hairs 1–1.5

mm long. *Anther* inserted about mid-way along column, ovoid, 3–3.8 mm long, 2–2.6 mm wide, connective produced into a beak 0.6–0.8 mm long; *pollinarium* 2.4–3 mm long; *viscidium* more or less circular, 0.7 mm diam.; *pollinia* white with coherent pollen. *Stigma* situated at base of column, ovate-quadrate, 2.5–3.5 mm long, 2.3–3 mm wide, margins irregular. *Capsules* obovoid, 12–18 mm long, 4–8 mm wide, erect, ribbed. (Fig. 3f)

***Selected specimens examined*: SOUTH AUSTRALIA.** Southern Lofty Region. Stock Road, Mylor, 18.x.2001, *R.J. Bates 60097* (MEL 2172087 & MEL 2172088); Northern Lofty Region. Jacobs Range Heritage Woodland, 10 km E of Blyth, 28.x.2001, *R.J. Bates 60131 & 60136* (MEL 2172098, MEL 2172099, MEL 2172096 & MEL 2172097); Near Moockra Tower, Mt Helen, 24.x.1996, *R.J. Bates 43060* (AD 99841300); Northern Lofty Region. Skillogalee via Clare, 24.x.1992, *R.J. Bates 29955* (AD 99319208); Southern Lofty Region. Para Wirra National Park, 30.x.1984, *D.J.E. Whibley 9621* (AD 98825164); Northern Lofty Region. Clare Hills, xi.2000, *R.J. Bates s.n.* (MEL 2100149); Southern Lofty Region. Kersbrook, 2 km N along main road to Williamstown, x.2000, *R.J. Bates 57793* (MEL 2100131); Ferguson Park, 12.x.1958, *R. Filson 1388* (MEL 622699); Northern Lofty Region. Clare Cemetery, x.1979, *R.J. Bates 532* (AD 98003053); Mt Lofty Range. National Park, Belair, 14.x.1906, *R.S. Rogers s.n.* (AD 97517132, BRI & NSW); Northern Lofty Region. Spring Gully Conservation Park via Clare, 7.xi.1999, *R.J. Bates 54946* (CANB 609400).

***Distribution and habitat*:** Apparently endemic to South Australia where found in the Southern Flinders Ranges, Northern Lofty and Southern Lofty Regions. Grows mostly in hill country in open forest, woodlands and grasslands, usually in moderately rich clay loam soils. Altitude: 50–700 m. (Fig. 4f)

***Conservation status*:** Widespread, sometimes locally common and well conserved.

***Flowering period*:** October to December.

***Pollination biology*:** The large, strongly scented flowers, easily spreading perianth, functional viscidium, coherent pollen and sporadic production of seed capsules would suggest that this species is entomophilous.

***Notes*:** *Thelymitra glaucophylla* is a robust species with a large distinctive pale green leaf with a whitish bloom. Natural hybrids between *T. glaucophylla* and *Thelymitra rubra* Fitzg. have been observed near Clare. Apparent natural hybrids between *T. glaucophylla* and *Thelymitra batesii* Jeanes have been observed near Kersbrook.

***Etymology*:** From the Greek *glauco*, bluish gray, *phylla*, a leaf; plants of this species have a large glaucous leaf.

13. *Thelymitra macrophylla* Lindl. in *Edwards's Bot. Reg.* 1–23: Sketch Veg. Swan R., app. 49 (213) (1839–40)

***Type*: WESTERN AUSTRALIA.** Swan River, 1839, *J. Drummond s.n.* (holotype K-L!, isotypes FI!, K!). *Syntypes*: Swan River, 1838, *J. Drummond s.n.* (BM!,AD!).

Illustrations: Nicholls (1969) plate 32 (as *T. nuda*); Hoffman & Brown (1998) page 269; Jones (2006) page 230; Brown *et al.* (2008) page 333, B; Hoffman & Brown (2011) page 326.

Glabrous terrestrial *herb*. *Tubers* ovoid, 1–3 cm long, 5–15 mm wide, fleshy. *Leaf* linear to linear-lanceolate, 15–30(–50) cm long, 5–25 mm wide, erect, canaliculate, leathery, dark green with a purplish base, ribbed abaxially, sheathing at base, apex acute. *Scape* 20–60(–105) cm tall, 1.5–10 mm diam., usually stout, straight, green to purplish. *Sterile bracts* usually 2 or 3, linear to linear-lanceolate, 2.5–16 cm long, 4–18 mm wide, lower bracts closely sheathing throughout, acute to acuminate, when 3 bracts present upper one often more or less free with the base only half encircling the inflorescence, green to purplish. *Fertile bracts* ovate-acuminate to obovate-acuminate, 5–40 mm long, 3–10 mm wide, sheathing the pedicels, green to purplish. *Pedicels* 2–27 mm long, slender. *Ovary* cylindric to narrow-obovoid, 5–15 mm long, 1–4 mm wide. *Flowers* 3–20(–25), (20–)30–50 mm across, usually dark blue to purplish, occasionally lilac, pink or white, often strongly scented, opening freely in warm weather. *Perianth segments* (10–)15–25 mm long, 5–12 mm wide, concave, sometimes stalked to spathulate, often shortly apiculate; *dorsal sepal* ovate, obtuse to subacute; *lateral sepals* lanceolate to ovate, slightly asymmetric, acute; *petals* ovate, obtuse to subacute; *labellum* elliptic to oblanceolate, acute, usually slightly smaller than other segments. *Column* erect from the end of ovary, (5.5–)6–8 mm long, (3–)3.5–5.5 mm wide, pale blue to pinkish; *post-anther lobe* hooding the anther, 3.5–5 mm long, 1.8–3 mm wide, tubular, hardly inflated, gently curved through c. 90°, dark brown to almost black, apex yellow, entire to shallowly emarginate, distal margin

irregularly toothed; *auxiliary lobes* often present as 2 tiny incurved spurs on the lower apical margin of the post-anther lobe; *lateral lobes* converging, 1.5–2 mm long, digitiform, porrect at base, bent upwards at c. 90° near the middle, each with a toothbrush-like arrangement of white hairs along the upper ½ to ¾ of their length, the individual hairs 0.8–1.2 mm long. *Anther* inserted about mid-way along column, ovoid, 2.5–3.5 mm long, 1.5–3 mm wide, connective produced into a beak 0.5–0.8 mm long; *pollinarium* 2–3 mm long; *viscidium* more or less circular, 0.5–1 mm diam.; *pollinia* white with coherent pollen. *Stigma* situated at base of column, ovate-quadrate, 2.5–3.5 mm long, 2–3.5 mm wide, margins irregular. *Capsules* obovoid, 12–25 mm long, 5–10 mm wide, erect, ribbed. (Fig. 5a)

***Selected specimens examined*: WESTERN AUSTRALIA.** Great Eastern Highway. John Forrest NP, Glen Forrest, 14.x.2000, *J.A. Jeanes 835, C. French & H. Beyrle* (MEL 2093602, MEL 2093603 & PERTH); 15.4 km W of the Frankland River along the Muirs Highway, 20.x.2000, *J.A. Jeanes 862, W. & G. Jackson* (MEL 2093600, MEL 2093601 & PERTH); Richardsons Rd Stoneville, c. 1.4 km W of Agnes Rd, 14.x.2000, *J.A. Jeanes 836, C. French & H. Beyrle* (MEL 2093604, MEL 2093605 & PERTH); Corner of Winnejup and Elwin Rds, Winnejup, 13.x.2001, *C.J. French 3183* (MEL 2172931 & MEL 2172932); Darling District. 90.1 km W of Mt Barker, 12.x.1991, *D.L. Jones 8364* (CANB 611756); 12 km E of Kwinana, 29.ix.1992, *N. Gibson & M.N. Lyon 1536* (PERTH 4521072); Serpentine Falls, 22.ix.1904, *A. Purdie s.n.* (PERTH 276278); 22 km SW of Frankland, 2.xi.1977, *A.S. George 15012* (PERTH 283487); Walpole, 2.xi.1974, *T. Wilson s.n.* (PERTH 284386); Lake Muir, 25.x.1978, *R. Heberle s.n.* (PERTH 273880); Warren National Park, 25.x.1959, *M.C. George s.n.* (PERTH 274321); Galamup Nature Reserve, 22.x.1997, *G.J. Keighery & N. Gibson 2330* (PERTH 5150345); Eucla Division. Esperance district: Buyi Billanak Homestead, 21.ix.1968, *D.G. Austin 106* (AD 97118089); Kamballup area, 25.x.1975, *M.A. Clements 194* (CANB 7800281).

***Distribution and habitat*:** Western Australia from Geraldton to east of Esperance. Grows mostly in higher rainfall near-coastal regions and in the ranges and hill country in habitats such as open forest, woodlands and heathy woodlands on well-drained sand and clay loams. Altitude: 10–500 m. (Fig. 6a)

***Conservation status*:** Widespread, often locally common and well conserved.

***Flowering period*:** Late August to November.

***Pollination biology*:** The easily spreading perianth, scented flowers, functional viscidium, coherent pollen and sporadic production of seed capsules would suggest that this species is entomophilous.

***Typification*:** The type sheet contains three specimens, apparently from a single collection. The left-hand specimen (which is in two parts) is about 60 cm tall, has a leaf about 23 cm long and 13 mm wide, about 15 flowers with perianth segments about 15 mm long. The two right-hand specimens have their lower inflorescence and leaf missing, but are consistent in flower number and size with the specimen on the left.

***Lindley's Latin description* (Lindley 1839–40):** Thelymitra macrophylla; *folio radicali erecto elongato lanceolato, racemo elongato cylindraceo, floribus purpureis, cuculli laciniis lateralibus parvis stuposis: intermedia majore fornicata glabra.* (Leaf radical, erect, elongate, lanceolate, raceme elongate cylindrical, flowers purple, hood lateral flap fringed: middle larger arched glabrous).

***Lindley's second Latin description* (Lindley 1840):** T. folio *radicali erecto lanceolato, racemo elongato cylindraceo, floribus purpureis, cuculli laciniis lateralibus parvis subsessilibus stuposis: intermedia majore fornicata glabra indivisa.* (Leaf radical, erect, lanceolate, raceme elongate cylindrical, flowers purple, hood lateral flap small subsessile fringed: intermediate larger arched glabrous entire).

***Notes*:** A somewhat stylised drawing by Lindley of a column in profile is on the lower right hand side of the sheet containing the holotype. This shows a rather inflated post-anther lobe and more or less straight lateral lobes with an elongate toothbrush-like arrangement of hairs. A more recent sketch by Clements (1984, unpublished) of a reconstituted flower from the holotype shows the post-anther lobe to be shallowly cleft at the apex and the lateral lobes to be relatively short, bent upwards sharply near the middle and have the hairs concentrated more towards the distal half. This latter depiction is more in keeping with Lindley's Latin description (Lindley 1840). Lindley (1840) also notes "A very tall species, apparently at least 2 feet [c. 60 cm] high, raceme about 20 flowered". Plants consistent with Lindley's description and notes, and with the type collection, are still common near Perth and many other parts of Western Australia and have been collected recently and studied. This taxon is relatively common and widespread throughout much of the higher rainfall parts of south-western Western Australia, but remains

poorly known today due to the presence of several superficially similar taxa, both in Western Australia and in the eastern states.

Thelymitra macrophylla has been confused with *T. paludosa*, but the latter usually flowers later (although there is some overlap), grows in wetter habitats, has a less robust habit, a generally narrower leaf and fewer, somewhat smaller flowers.

Plants similar to *T. macrophylla* from north of Geraldton and near Beacon (Hoffman & Brown 2011) are in need of study.

Thelymitra macrophylla apparently hybridises with *Thelymitra flexuosa* Endl., *Thelymitra crinita* Lindl., *Thelymitra vulgaris* Jeanes and *T. antennifera* the latter giving rise to plants with flowers very similar to the eastern Australian *T.* ×*macmillanii* (Hoffman & Brown 1998; Jones 2006; Brown *et al.* 2008).

14. *Thelymitra alpina* Jeanes, *sp. nov.*

Type: **NEW SOUTH WALES.** Southern Tablelands. Kosciuszko National Park, *c.* 5.3 km along Tantangara Dam Road, 13.xii.1997, *D.L.Jones 15642 & B.E. Jones* (holotype CANB 9908940; isotype CANB).

Illustrations: Nicholls (1969), plate 28 (as *Thelymitra aristata*); Backhouse & Jeanes (1995), page 354 (as *T. nuda*); Jeanes & Backhouse (2006), page 218, A–D (as *Thelymitra* sp. aff. *megcalyptra 2*); Jones (2006) page 229.

Glabrous terrestrial *herb*. *Tubers* ovoid, 1–3 cm long, 0.5–1.5 cm wide, fleshy. *Leaf* linear-lanceolate to lanceolate, 10–32 cm long, 5–15 mm wide, erect, canaliculate, fleshy, dark green with a purplish base, ribbed abaxially, sheathing at base, apex acute. *Scape* 15–45(–80) cm tall, 1.5–4.5 mm diam., slender to stout, straight, green to purplish. *Sterile bracts* usually 2, sometimes 3, linear to linear-lanceolate, 2–7(–12) cm long, 4–10 mm wide, closely sheathing, green to purplish, acute to acuminate. *Fertile bracts* ovate-acuminate to obovate-acuminate, 5–20(–30) mm long, 3–7 mm wide, sheathing the pedicels, green to purplish. *Pedicels* 1–12(–25) mm long, slender. *Ovary* cylindric to narrow-obovoid, 5–14 mm long, 1–3.5 mm wide. *Flowers* 2–10(–20), (20–)25–40 mm across, usually blue to purplish, occasionally lilac, pink or white, opening freely in warm weather. *Perianth segments* (9–)15–20(–25) mm long, 3–11 mm wide, concave, somewhat stalked to spathulate, apex acute to obtuse, often shortly apiculate; *dorsal sepal* ovate; *lateral sepals* lanceolate to ovate, slightly asymmetric; *petals* ovate; *labellum* elliptic to oblanceolate, usually narrower than other segments. *Column* erect from the end of ovary, 5.5–7 mm long, 3–4 mm wide, pale blue to pinkish; *post-anther lobe* hooding the anther, 3.5–5 mm long, 2–3 mm wide, tubular, very inflated, often somewhat compressed dorsally, gently curved through c. 90°, pale to dark brown, apex yellow, bilobed, lobes irregular, to *c.* 1.5 mm long, distal margin irregularly toothed, usually also with two prominent forward-pointing horn-like teeth, orifice small; *auxiliary lobes* often present as 2 tiny incurved spurs on the lower apical margin of the post-anther lobe; *lateral lobes* converging, 1–2 mm long, digitiform, porrect at base, curved upwards, each with a toothbrush-like arrangement of white or pinkish hairs along the upper ½ to ¾ of their length, the individual hairs 0.8–1.2 mm long. *Anther* inserted about mid-way along column, ovoid, 2.5–3.5 mm long, 1.5–2.5 mm wide, connective produced into a beak 0.4–1 mm long; *pollinarium* 2–2.6 mm long; *viscidium* more or less circular, c. 0.6 mm diam.; *pollinia* white with coherent pollen. *Stigma* situated at base of column, ovate-quadrate, 2–3 mm long, 2–3 mm wide, margins irregular. *Capsules* obovoid, 10–20 mm long, 4.5–8 mm wide, erect, ribbed. (Fig. 5b)

***Selected specimens examined*: NEW SOUTH WALES.** Southern Tablelands: *c.* 5 km along Tantangara Dam Road, 2.xii.1990, *D.L. Jones 7260* (CANB 9016526); Southern Tablelands: Kosciuszko National Park, c. 4 km along Tantangara Dam Road, 10.xii.1994, *D.L. Jones 13759 & B.E. Jones* (CANB 609326); Tantangara Dam, 29.xi.1987, *R.J. Botes s.n.* (AD 98746537); Southern Tablelands: Kosciuszko National Park, south side of Cave Creek, 1.5 km downstream of Blue Waterholes, 9.xii.199B, *N.G. Walsh 4881 & K.L. McDougall* (MEL 2054134); Southern Tablelands: *c.* 6.5 km by road WSW of Klandra, 28.xii.1994, *J.A. Jeones 132* (MEL 2025003); Southern Tablelands: between Kiandra and Cabramurra; top of the Great Dividing Range at 3 Mile Dam, 21.xii.19BS, *M.A. Clements 3932* (CANB 850SS84); Southern Tablelands: Brindabella area towards Tumut, B.xii.198S, *M.A. Clements 3899* (CANB BS055S1); Southern Tablelands: Gold Seekers Trail, 3 Mile Dam area, Mt Selwyn, 14.i.1993, *D.L. Jones 11190 & C.H. Broers* (CANB 609327); Brindabella Range, Coree Flat, 2B.xi.196B, *E.M. Conning EMC1328* (CANB 068431); Southern Tablelands: Kosciuszko National Park, 2.2 km up Ravine Road from Snowy Mountains Highway, 14.xii.2001, *D. Rouse JAJ1286* (MEL 2172092 & MEL 2172093). **AUSTRALIAN CAPITAL TERRITORY.** Bendora Dam Road, *c.* 10 km from Bulls Head, 2.xii.19B9, *D.L. Jones 5445 & B.E. Jones* (CANB

8913975); Blue Gum Creek (upper Paddys River) c. 2 miles SW of 'Booroomba' station, 29.xi.1960, *R. Pullen 2406* (CANB 86267); One mile S of Forest Rangers hut, Upper Cotter, Bimberi Creek, 14.xii.1960, *P. Dorbyshire 62* (CANB 87344 & NSW); Nursery Swamp, Namadgi National Park, 3.xii.1998, *D.J. Mollinson ORG1978* (CANB 609325). **VICTORIA.** Eastern Highlands. Bundara River, 11.xi.1999, *P.G. Bronwhite 65 & 66* (CANB 609390 & CANB 612484); Eastern Highlands. Cravensville, 5.xi.1999, *P.G. Bronwhite 51* (CANB 610973); Snowfields. Alpine National Park, Wonnangatta-Moroka unit. Walking track from Bryce Gorge carpark towards Piemans Ck Falls, 16.xii.2000, *N.G. Walsh 5279* (MEL 2089868 & MEL 2089869); Wulgulmerang, 25.xii.1985, *R.J. Bates 6673* (AD 98608155); North-east. Benambra-Corryong Rd c. 64 km S of Nariel, 1.xi.1977, *M.G. Corrick 6013* (MEL 533532); Burbibyong Creek Reference Area, 26.x.1987, *A.C. Beauglehole 89462 & L.W. Huebner* (MEL 238616); Mitta Mitta Reference Area, 10.xi.1987, *A.C. Beauglehole 91326 & C.C. Taylor* (MEL 238617); Eastern Highlands. 3 km along Knocker Tk (Burnside Track intersection) from Omeo Valley Rd intersection, 6.xi.1983, *C.W. Huggins 56* (MEL 630352); Snowfields. 4 miles NE of Mt Arbuckle, on Doolans Plain Rd, 17.i.1967, *T.B. Muir 4528* (MEL 221676); North-east. 17.5 km S from Whitfield, on Wabonga Track in Wabonga Plateau State Park, 19.xi.1986, *A.D.J. Piesse 559* (MEL 1557426 & MEL 2039568); Eastern Highlands. Bundarra River, near Anglers Rest, 29.xi.1989, *P. Bronwhite DLJ5442* (CANB 8913972); Eastern Highlands. Blue Plain Spur, 3.2 km S of Saltlick Saddle/Blue Plain Spur Track junction, ?i.1978, *N.G. Walsh & P.K. Gullen 955* (MEL 629692).

***Distribution and habitat*:** Alpine, sub-alpine and montane areas of south-eastern New South Wales, the Australian Capital Territory and eastern Victoria. Grows in alpine and sub-alpine meadows and woodlands often dominated by Snow Gums, or in open montane forests. Substrates are usually sandy and peaty loams. Altitude: 500–1600 m. (Fig. 6b)

***Conservation status*:** Widespread, sometimes locally common and well conserved.

***Flowering period*:** Late October to January.

***Pollination biology*:** The large, freely opening flowers, functional viscidium, coherent pollen and sporadic capsule production would suggest that this species is entomophilous

***Notes*:** *Thelymitra alpina* differs from *T. megcalyptra* in its high altitude, more mesic habitat, usually shorter leaf and more elongate, dorsally compressed post-anther lobe that has an irregularly toothed apical margin often with two forward-pointing horn-like teeth.

Thelymitra alpina sometimes grows with *Thelymitra simulata* D.L.Jones & M.A.Clem. and apparent hybrids have been observed near Kiandra in the Kosciuszko National Park.

***Etymology*:** From the Latin *alpina*, of the alps; the species most often grows in alpine and sub-alpine habitats.

15. *Thelymitra megcalyptra* Fitzg., *Austral. Orch* 1(5): t. 2 (1879)

Type: **NEW SOUTH WALES.** Deniliquin, x., *R.D. Fitzgerald* s.n. (lectotype specimen (a) BM!, *fide* Clements 1989, isolectotype AD!). *Syntype*: Lake George, x., *R.D. Fitzgerald* s.n. (BM!).

Thelymitra aristata Lindl. var. *megcalyptra* (Fitzg.) Nicholls in J.M. Black, *Fl. South Australia* ed. 2, 1: 215 (1943).

Illustrations: Fitzgerald (1879) 1: 5; Nicholls (1969) Plate 30 (as *T. aristata* var. *megcalyptra*); Backhouse & Jeanes (1995) page 351; Jeanes & Backhouse (2006) page 217; Jones (2006) page 231; Bates (2011) pages 73 & 74.

Glabrous terrestrial *herb*. *Tubers* ovoid, 1–2 cm long, 5–10 mm wide, fleshy. *Leaf* linear to linear-lanceolate, 10–30 cm long, 5–15 mm wide, erect, canaliculate, fleshy, dark green with a purplish base, ribbed abaxially, sheathing at base, apex acute. *Scape* 20–60 cm tall, 1.5–5 mm diam., slender to stout, straight, green to purplish. *Sterile bracts* usually 2, linear to linear-lanceolate, 1.5–7.5 cm long, 4–12 mm wide, closely sheathing, green to purplish, acute to acuminate. *Fertile bracts* ovate-acuminate to obovate-acuminate, 5–26 mm long, 3–7 mm wide, sheathing the pedicels, green to purplish. *Pedicels* 1–15 mm long, slender. *Ovary* cylindric to narrow-obovoid, 6–12 mm long, 1.5–3.5 mm wide. *Flowers* 2–15, (20–)30–40 mm across, usually dark blue to purplish, occasionally lilac, pink or white, opening freely in warm weather. *Perianth segments* (9–)15–22 mm long, 4–11 mm wide, concave, often somewhat stalked to spathulate, apex acute to obtuse, often shortly apiculate; *dorsal sepal* ovate; *lateral sepals* lanceolate to ovate, slightly asymmetric; *petals* ovate; *labellum* elliptic to oblanceolate, usually narrower than other segments. *Column* erect from the end of ovary, (5–)6–8 mm long, (2.5–)3–4.7 mm wide, pale blue to pinkish; *post-anther lobe* hooding the anther, 3.5–4.5 mm long, 1.8–3 mm wide, tubular, usually very inflated, gently curved through c. 90°, pale to dark brown, apex yellow, bilobed,

lobes irregular, to c. 1 mm long; *auxiliary lobes* often present as 2 tiny incurved spurs on the lower apical margin of the post-anther lobe; *lateral lobes* converging, 1.5–2.2 mm long, digitiform, porrect at base, curved upwards, each with a toothbrush-like arrangement of white hairs along the upper ½ to ¾ of their length, the individual hairs 0.8–1.2 mm long. *Anther* inserted about mid-way along column, ovoid, 2.5–3.5 mm long, 1.5–2.5 mm wide, connective produced into a beak 0.4–0.7 mm long; *pollinarium* 2–3.3 mm long; *viscidium* more or less circular, c. 0.6 mm diam.; *pollinia* white with coherent pollen. *Stigma* situated at base of column, ovate-quadrate, 2.3–3 mm long, 2–3 mm wide, margins irregular. *Capsules* obovoid, 10–20 mm long, 5–8 mm wide, erect, ribbed. (Fig. 5c)

***Selected specimens examined*: SOUTH AUSTRALIA.** Wilpena Pound, about 6 km SW of Chalet, near foot of Dick's Nob, 28.viii.1974, *T.B. Muir 5325* (MEL 114560 & MEL 2039739); Yorke Peninsula: Mulburra Park Conservation Reserve, 3.ix.2000, *D.L. Jones 17255* (MEL 2087463, MEL 2089296 & CANB); Railway enclosure c. 2 miles (3 km) E of Tintinara, 28.ix.1961, *J.H. Willis s.n.* (MEL 114558 & MEL 221672); Eyre Peninsula: SW of Wanilla Railway Siding, Hundred of Wanilla, 5.x.1967, *C.R. Alcock 2696D & 2696B* (AD 98839144, AD 98839146, MEL 2067264, MEL 2067263, CANB 524788 & CANB 524787); Stansbury Scrubs, c. 5.3 km W along road to Minlaton, 3.ix.1999, *D.L. Jones 16663 & M. Gorrott* (CANB 607255 & AD); South-east District: Desert Camp Park, southern side of Keith–Padthaway Road, 14.ix.1999, *D.L. Jones 16949 & M. Gorrott* (CANB 606837); Mulburra Park Flora Reserve, near Port Vincent, 2.ix.1999, *D.L. Jones 16631 & M. Gorrott* (CANB 607222); South-east District: 6.8 km W of Coonalpyn towards Meningie, 14.ix.1999, *D.L. Jones 16912 & M. Gorrott* (CANB 606800 & AD); Yorke Peninsula: Rail Reserve above Lochiel turnoff, Bute–Snowtown Road, 27.viii.1966, *B. Copley 539* (AD 96643216); Lower Murray Mallee: Monarto South, c. 15 km W of Murray Bridge on Adelaide–Melbourne railway, 26.ix.1936, *W. Giles 863* (AD 97631486). **NEW SOUTH WALES.** Moama, x.1891, (NSW 462446); Central-west Slopes. Holy Camp, Weddin Mountains National Park, 14.x.1999, *M. Gorrott ORG275B & K.J. Fitzgerald* (CANB 611758); Central-west Slopes. Weddin Mountains National Park, in camp ground, c. 15 km W of Grenfell, 23.x.1989, *A.M. Lyne 17* (CANB 9012015); Central Tablelands. Mullion Range, c. 6 km along Ophir Road, N of Mullion Creek, 24.x.1989, *D.L. Jones 5299* (CANB 8913829); South-west Slopes. Nailcan Range, Albury, 17.x.1998, *P.G. Bronwhite ORG1639* (CANB 609386); Cocoparra National Park, Woolshed Creek area, 4.x.1971, *J.W. Wrigley s.n.* (CANB 42233); 6 miles N of Junee on highway, 3.x.1963, *I.G. Motthios s.n.* (CANB 64975); Central-west Slopes. Kangarooby, 22.x.1966, *B. Whitehead s.n.* (CANB 8104449, CANB 8104450 & CANB 8104451); Merrimerriwa Range, along S boundary fence of Yathong Nature Reserve, 11.x.1983, *K. Hill 114 & L. Johnson* (NSW 465653); 22.6 km S of Rye Park on Boorowa–Yass Rd, 16.x.1980, *R. Coveny 10754 & P.D. Hind* (NSW 412016 & CANB 509588); Warrambungle National Park, Belougery Split Rock, 10.ix.1988, *W. Greuter 20647* (MEL 2199225 & NSW 462476).

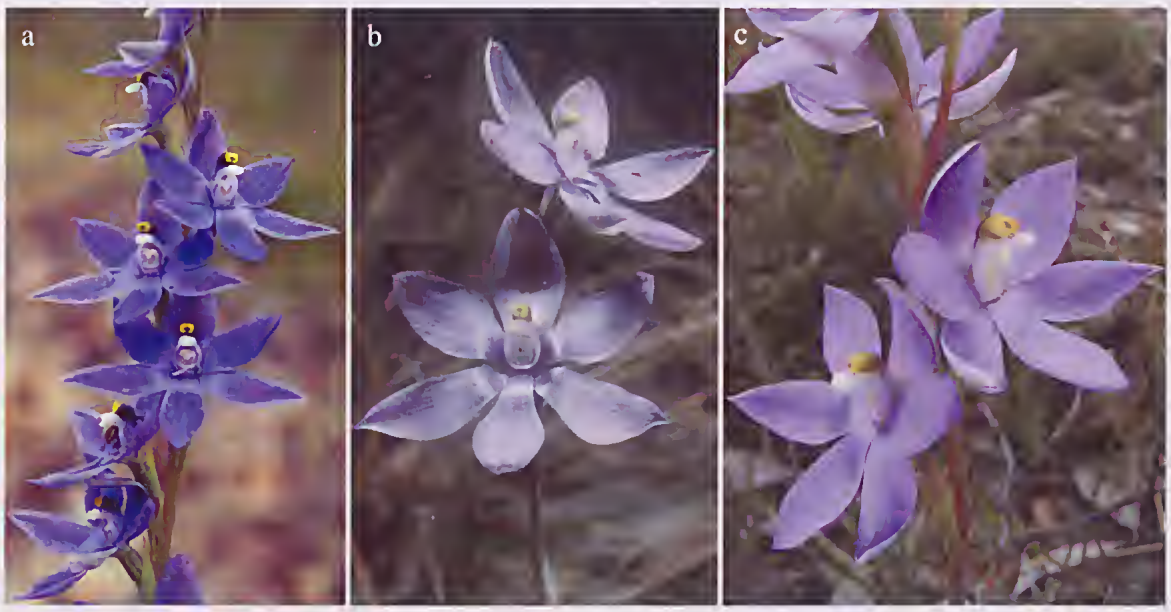

Figure 5. a. *Thelymitro mocrophyllo*, Rocky Gully, WA (photograph by J.A. Jeanes); **b.** *T. olpino*, Snowy Plains, Vic. (photograph by J.A. Jeanes); **c.** *T. megcolyptro*, Deep Lead, Vic. (photograph by J.A.Jeanes)

AUSTRALIAN CAPITAL TERRITORY. 8lack Mountain, section W of Caswell Drive, 9.xi.1975, *J.H. Webb s.n.* (CAN8 506689); Bulls Head to Bendora Dam Rd, 31.x.1963, *M. Gray 5346* (CANB 505955); Mt Ainslie, 29.x.1991, *C.H. Broers 232 & D.L. Jones* (CAN8 91094B3); Gibraltar Falls, 2.xi.1991, *C.H. Broers 255 & P. Branwhite* (CANB 9219B40); Corin Forest, on Corin Dam Road, 17.xi.1991, *M.A. Clements 7666* (CANB 611757); Hill E of Cotter River crossing, Cotter Hut Rd, Namadgi National Park, 30.xi.199B, *D.L. Jones 16224, M. Gorratt & K.J. Fitzgerold* (CANB 611755, MEL 20B9292 & NSW); Kowen Pine Forest, 18.xi.1964, *M. Groy 5584* (CANB 505941); Black Mountain, W side adjacent to Aranda, 1.xi.19B9, *D.L. Jones 5335 & B.E. Jones* (CAN8 8913865); 8 km S of Gibraltar Falls on Corin Rd, 27.xi.1984, *G. Stewort 400, B. O'Sheo & S. Young* (CAN8 8413192). **VICTORIA.** Murray Valley: Warby Range, 15 km 5W of Wangaratta, 5.xi.1985, *A.D.J. Piesse 91* (MEL 1543154); Chiltern 5tate Park, 5keleton Boundary Track 200 m in from Lancashire Gap Road, 16.x.1989, *J. Strudwick JS433* (MEL 1576B57); Riddell rail enclosure, xi.1941, *W.H. Nicholls s.n.* (MEL 650292); North-west: 8ig Desert, 13 km S of Murrayville on the Nhill Road, 2.x.1979, *M.G. Corrick 6366* (MEL 1515757); Big Desert. Wyperfeld National Park, 7.7 km ENE from Ring Road, 10.x.1990, *N.G. Walsh 2997* (MEL 1598339 & MEL 2045489); Cemetery at Kingower, *c.* 7 miles SW of Inglewood, 9.x.1960, *T.B. Muir 1371* (MEL 221679); Railway line 2 miles E of Heathcote, xi.1964, *D.L. Jones s.n.* (MEL 649023 & MEL 648745); Whroo Forest. Whroo, 7 km S5W of Rushworth, 27.x.1974, *T.B. Muir 5375* (MEL 114544 & CANB 8309420); Western Highlands region: Lake Fyans area, 1B.xi.1996, *D.L. Jones 14973 & M. Gorrott* (CAN8 990B963); Anglesea, near summit of Mt Ingoldsby, 24.x.1966, *D.L. Jones s.n.* (CANB 523996 & CANB 980026B).

***Distribution and habitat*:** South Australia, New South Wales, Australian Capital Territory and Victoria. Grows mostly in drier inland habitats such as open forest, woodlands and mallee scrublands on well-drained sand and clay loams. Altitude: 10–1000 m. (Fig. 6c)

***Conservation status*:** Widespread, often locally common and well conserved.

***Flowering period*:** Late August to November.

***Pollination biology*:** The easily spreading perianth, functional viscidium, coherent pollen and sporadic production of seed capsules would suggest that this species is entomophilous.

***Typification*:** The type sheet contains four specimens and two labels. The left-hand specimen (a) was designated by Clements (1989) as the lectotype. The remaining three specimens are from a different collection and are probably syntypes. All four specimens appear to be of the same species although the one on the left is more robust and has somewhat larger flowers. The lower part of the inflorescence and the leaf are missing from all specimens.

***Notes*:** Plants consistent with Fitzgerald's description, illustration and notes on *Thelymitra megcalyptra*, and with the type collection, can still be found in southern New South Wales in the vicinity of the type locality and have been collected recently and studied. This taxon is relatively common and widespread throughout much of inland south-eastern Australia, but remains poorly known today due to the presence of several superficially similar taxa. The degree of inflation of the post-anther lobe is variable within and between populations,

Figure 6. Distribution of **a.** *Thelymitra macrophyllo*; **b.** *T. alpina*; **c.** *T. megcalyptro*

and, used by itself, this character is unreliable for identification purposes.

Thelymitra megcalyptra hybridises with *Thelymitra luteocilium* Fitzg. (to produce *Thelymitra* ×*chasmogama* R.S. Rogers) and with *T. antennifera* (Jones 2006)

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CSIRO = CSIRO, Centre for Plant Biodiversity Research (ACT)

DEC = Department of Environment and Conservation (WA)

MEL = National Herbarium, Melbourne (Vic.)

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The lichen genus *Lecidella* (Lecanoraceae), with special reference to the Tasmanian species

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Introduction

In continuing our review of *Lecidea*-like crustose lichens in temperate Australia (e.g. Kantvilas & Elix 1994, 2007; Kantvilas *et al.* 1999, 2005; Kantvilas 2001, 2008a, 2008b, 2009, 2011; Kantvilas & La Greca 2008), we have turned our attention to the genus *Lecidella* Körb. This genus of approximately 50 species (Kirk *et al.* 2001) is well represented in all major regions of the world including Antarctica (Øvstedal & Lewis Smith 2001). It occurs mostly in cold or cool temperate climates where it colonises rocks, bark, wood and soil, as well as man-made substrata such as concrete; several species are particularly adapted to eutrophicated habitats.

Although *Lecidella* has not been the subject of a comprehensive revision in Australia, four species were treated by Rambold (1989) in his account of mainland Australian lecideoid lichens. Australian taxa and collections have also been studied in the course of a series of papers by J.-G. Knoph and co-workers, who greatly advanced the chemotaxonomic knowledge of the genus (Knoph 1990; Knoph *et al.* 1999; Knoph & Leuckert 2000). Miscellaneous reports of species from Australia, including new state records, have also been added by Allen *et al.* (2001), Elix (2006, 2008, 2010), Elix and Kantvilas (1995), Hertel (1985, 1989, 1990) and Kantvilas *et al.* (2008). In his checklist of Australian lichens, McCarthy (2012) records eight species for Australia, of which four occur in Tasmania. Meanwhile, Galloway (2007) treats nine species for New Zealand and provides a good overview of the genus, which is of particular relevance to the Australasian region.

The present study is essentially Tasmanian in focus, although we have also studied many additional collections from elsewhere in southern Australia in order to provide a context for our work. We recognise eight species, of which three are described as new, and transfer to *Lecidella* a further taxon previously included within *Lecidea*.

Abstract

Eight species of *Lecidello* (Lecanoraceae, lichenised Ascomycetes) are recorded for Tasmania: *L. destituta* Kantvilas & Elix *sp. nov.*, *L. elaeochromo* (Ach.) Hazsl., *L. flavovirens* Kantvilas & Elix *sp. nov.*, *L. granulosula* (Nyl.) Knoph & Leuckert, *L. stigmatea* (Ach.) Hertel & Leuckert, *L. sublapicida* (C. Knight) Hertel and *L. xylogena* (Müll. Arg.) Kantvilas & Elix *comb. nov.* (all present in mainland Australia), and the Tasmanian endemic *L. montono* Kantvilas & Elix *sp. nov.* All species are described in full, and notes on their characterisation, inter-relationships, distribution and ecology are provided. The status of the names *Lecidea minutula* Müll. Arg. and *L. leptolomoides* Müll. Arg., based on collections from Victoria, is discussed briefly.

Key words: blodiversity, *Lecideo*, lichenised Ascomycetes, temperate Australia

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Materials and methods

The study is based chiefly on collections by the authors, housed mainly in the Tasmanian Herbarium (HO) and on selected collections from other herbaria as cited in the text. Diagnostic characters of non-Tasmanian species, studied for comparative purposes, were determined from reference herbarium material (mainly from HO), and from published descriptions.

Descriptions are based on hand-cut sections of the thallus and ascomata, examined with high-power light microscopy. Mounting media included water, 15% KOH (K), Lugols Iodine after pretreatment with K, Lactophenol Cotton Blue after pretreatment with K and washing with water, and 50% HNO_3 (N). Dimensions of asci and ascospores are based on 25 and 60–100 observations respectively. The latter are presented in the format: 5th percentile–*mean*–95th percentile; outlying extreme values are given in parentheses. Routine chemical analyses using thin-layer chromatography follow standard methods (Orange *et al.* 2001). Critical extracts of a representative selection of specimens of each taxon were analysed using high-performance liquid chromatography (Elix *et al.* 2003).

Characteristics of the genus and species

Lecidella is characterised by: a crustose thallus containing a trebouxioid photobiont with ± globose cells 6–18 µm diam.; biatorine apothecia that are typically a shade of brown or black and include blue-green, N+ crimson pigments [essentially *cinereorufa green* of Meyer and Printzen (2000)]; a persistent, typically annular proper excipulum composed of radiating, thick-walled hyphae *c.* 3–5 µm thick that become expanded to *c.* 5–10 µm and increasingly paraplectenchymatous and internally pigmented towards the outer edge; clavate, eight-spored asci with the outer wall amyloid, a well-developed, intensely amyloid tholus, almost but not completely penetrated by a weakly amyloid, ± conical *masse axiale* with a rounded apex, and a poorly developed ocular chamber; mostly simple paraphyses that usually separate readily in KOH; and simple, hyaline, non-halonate ascospores with a distinct, thin, single-layered wall when mature. In the literature, the asci are mostly referred to as '*Lecanora*-type' although they are more accurately described as *Lecidella*-type, as illustrated by Hafellner (1984). In *Lecanora*, the asci differ subtly by having the tholus penetrated *entirely* by the cylindrical to barrel-shaped *masse axiale*. Chemistry of the genus is variable and very frequently includes a suite of xanthones.

At generic rank, *Lecidella* is usually not difficult to recognise, although there are some superficially similar genera, including *Carbonea* (Hertel) Hertel, *Japewiella* Printzen, *Mycoblastus* Norman, *Megalaria* Hafellner, *Tasmidella* Kantvilas, Hafellner & Elix and *Ramboldia* Kantvilas & Elix, with which it has some features in common. Salient features of these taxa are summarised in Table 1. In the course of the present study, we found that the genus most likely to be confused with *Lecidella* was *Japewiella*, which has ± identical asci, a lax hymenium and, frequently, a xanthone-dominated thallus chemistry. The main difference between the two genera is that the excipulum of *Japewiella* consists of a loose reticulum of radiating, branched and anastomosing hyphae *c.* 1 µm thick in a gelatinous matrix (Printzen 1999; Kantvilas 2011). Several undescribed species of *Japewiella* were recognised during the present work and await study in the future.

Thallus morphology and chemistry, apothecial pigmentation and ascospore dimensions are the chief characters by which species of *Lecidella* are circumscribed. Chemistry is particularly critical, complicated by the fact that identification of the many xanthones present, as well as distinguishing such key compounds as vicanicin and diploicin, is difficult and essentially requires high-performance liquid chromatography. Determination of the chemistry of each specimen was an essential aspect of this study. Yet, having circumscribed the species, it was found that each can usually be identified without difficulty using morphological and anatomical characters, and so distinguishing the different species is not necessarily limited to the practitioner with access to specialist laboratory equipment.

Taxonomy

1. ***Lecidella destituta*** Kantvilas & Elix, ***sp. nov.***

MycoBank No.: MB803599

Lecidellae elaeochromae *aemulans sed atranorinum solum continenti et hymenio guttis olei crystalisque insperso differt.*

Table 1. Comparison of salient features of *Lecidella* and superficially similar genera (based on observation of selected specimens and literature)

	Lecidella	*Mycoblastus s. str. (M. sanguinarius* group)[1]	*Mycoblastus dissimulans* group[1]	*Megalaria s. lat.*[2,3,4]	*Tasmidella*[5]	*Ramboldia*[6,7]	*Japewiella*[8,9,10]	*Carbanea*[11,12]
excipulum	persistent, composed of radiating, thick-walled hyphae that become parapectentchymatous and internally pigmented at the outer edge	reduced, soon excluded, composed of short-celled, reticulate hyphae	reduced, soon excluded, composed of branched and anastomosing hyphae similar to paraphyses	persistent, two-layered, composed of branched and anastomosing, radiating hyphae	persistent, composed of branched and anastomosing, radiating hyphae	typically reduced and soon excluded, composed of branched and anastomosing, radiating hyphae	persistent, composed of branched and anastomosing hyphae	persistent to excluded, typically opaque and carbonised
apathecial pigments	cinereorufa-green	cinereorufa-green, subapothecial red pigments	cinereorufa-green, fucatus-violet	cinereorufa-green, atra-red, hypnorum-blue	cinereorufa-green, hypnorum-blue	mostly brown, K± olive, N–, or red, K+ purple anthraquinones in some species	red-brown, K± olive, N–	various blue-green, red-brown and brown pigments
paraphyses	mostly simple and separating easily in KOH	branched and anastomosing, coherent in KOH	branched and anastomosing, coherent or separating in KOH	simple, or occasionally branched and anastomosing	mainly simple and separating easily in KOH	sparsely branched and anastomosing, coherent or separating in KOH	mainly simple, separating in KOH	simple to sparsely branched, coherent in KOH
asci	*Lecidella*-type, 8-spored; *masse axiale* ± conical with a rounded apex	*Mycoblastus*-type, 1-spored; *masse axiale* reduced to a pale border to the ocular chamber	*Mycoblastus*-type, or *Biatora*- to *Lecidella*-type, 2(–4)-spored; *masse axiale* barrel-shaped to conical	± *Lecanora*-type with *masse oxiole* barrel-shaped (*M. grossa*) or *Biatora*-type with *mosse axiale* conical; 2–8-spored	± *Leconoro*-type, 8-spored; *mosse axiole* ± conical	*Lecanora*-type, 8-spored; *masse axiale* cylindrical to broadly diverging	*Lecidello*-type, 8-spored; *mosse axiole* ± conical with a rounded apex	*Lecanora*-type, 8-spored; *masse axiale* cylindrical
ascaspares	simple, broadly ellipsoid to oblong, single-walled, mostly ≤ 17 µm (to 24 µm in *L. montono*)	simple, ellipsoid to oblong, double-walled, mostly 60–100 µm long	simple or rarely 1-septate, ellipsoid to ovate, double-walled, mostly 30–60 µm long	ellipsoid to ovate, 1-septate, single-walled, to 45 µm long	simple or rarely 1-septate, narrowly ellipsoid, double-walled, to 20 µm long	simple, narrowly ellipsoid, single-walled, to 14 µm long	simple, ellipsoid, single-walled, to 20 µm long	simple, ellipsoid, single-walled, to 17 µm long
chemistry	mostly xanthones, ± atranorin, ± zeorin, ± depsidones	atranorin, ± depsides, ± depsidones, ± fatty acids	perlatolic acid, ± depsidones, ± fatty acids	nil, ± atranorin, ± zeorin, ± depsidones	atranorin or xanthones	usually depsides or depsidones, rarely xanthones or fatty acids	atranorin, ± xanthones, ± depsides	atranorin, ± xanthones, ± zeorin, ± depsides, ± depsidones

[1] Kantvilas (2009); [2] Ekman & Tønsberg (1996); [3] Fryday & Lendemer (2010); [4] Kantvilas (2008b); [5] Kantvilas *et al.* (1999); [6] Kantvilas & Elix (1994); [7] Kantvilas & Elix (2007); [8] Printzen (1999); [9] Spribille & Printzen (2007); [10] Kantvilas (2011); [11] Chambers *et al.* (2009); [12] Knoph *et al.* (2004)

Type: **NEW SOUTH WALES.** Gillenbah State Forest, 8 km S of Narrandera, 34°47′51″S 146°30′00″E, 170 m alt., on *Callitris* in mallee scrub, 16 April 2009, *J.A. Elix 39928* (holotype: HO; isotype: CANB).

Thallus typically areolate, deeply cracked, rather lumpy and uneven, more rarely very thin, effuse and revealing a blue-black prothallus beneath, pale pinkish brown, grey-brown to whitish grey, undelimited, esorediate, forming irregular patches *c.* 1–5 cm wide. *Apothecia* 0.2–0.9 mm wide, sessile, basally constricted; disc mostly persistently plane, sometimes becoming undulate but only rarely convex, black, matt, epruinose. *Proper excipulum* black, matt to glossy, persistent, entire, in section 20–40 µm thick, ± opaque brown within, unchanged in K, N+ intensifying orange-brown, also with additional blue-green, N+ crimson pigment, especially at the upper and outer edges. *Hypothecium* 40–90 µm thick, pale yellow-brown to yellow-orange, intensifying yellow-orange in K and N. Hymenium 60–90 µm thick, separating easily in K, not overlain by epihymenial granules but densely inspersed, especially towards the base, with minute, colourless crystals and oil droplets that do not dissolve in K, in the upper part intensely greenish blue, K ± grey-green, N+ crimson, towards the base mostly colourless, often K± very faint pinkish. Asci 45–60 × 14–22 µm. *Paraphyses* 1.5–2.5 µm thick, simple; apices usually expanded to 2–4.5 µm thick, mostly with an external, blue-green, N+ crimson cap but sometimes unpigmented. *Ascospores* broadly ellipsoid, occasionally slightly bent, 11–*13.7*–16(–17) × (5.5–)6–*7.2*–9 µm. *Conidiomata* not observed. Fig. 1A

Chemical composition: atranorin , ±chloroatranorin; thallus K± yellowish, P–, KC–, C–, UV–.

Remarks: This species is characterised chiefly by the combination of the thallus containing atranorin only, and by the conspicuously inspersed hymenium. In other respects, such as disposition of pigments and the yellow-brown hypothecium, it is very similar to *Lecidella elaeochroma*. Additional, more subtle characters that distinguish *L. destituta* from *L. elaeochroma* include the apothecia, which generally do not become markedly convex with an excluded exciple, and the lack of brownish epihymenial granules; the ecology of the two taxa (see below) is also starkly different. Although the ascospores of *L. destituta* fall within the size range of *L. elaeochroma*, they are nevertheless slightly longer and broader (as demonstrated by mean values). It is probably due to the lack of epihymenial granules that the blue-green apothecial pigment in *L. destituta* often appears relatively bright. The characteristic inspersion of the hymenium is most pronounced in New South Wales and South Australian specimens, whereas in Tasmanian material, this is mostly restricted to the base of the hymenium. The crystals and droplets do not fluoresce in polarised light, nor dissolve in KOH or HNO_3, but they yield a curious pinkish reaction in the former reagent. In the field, *L. destituta* is most likely to be confused with species of the *Buellia disciformis* (Fr.) Mudd group.

A thallus chemistry comprising atranorin only is unusual in *Lecidella*. In some Northern Hemisphere accounts (e.g. Poelt & Vězda 1981; Fletcher *et al.* 2009), *L. euphorea* (Flörke) Hertel is alluded to as being a xanthone-deficient relative of *L. elaeochroma*. Initially we entertained the notion that this could be an appropriate name for our Australian collections. However, every herbarium specimen labelled as *L. euphorea* that we were able to study (from Europe and North America) invariably contained xanthones (when examined by h.p.l.c). Furthermore, in their account of Sonoran species, Knoph and Leuckert (2004) consider *L. euphorea* as containing either atranorin only or atranorin plus xanthones. In their concept, the species also lacks an inspersed hymenium. Another species examined was the European *L. achristotera* (Nyl.) Hertel & Leuckert. This species is very similar to *L. destituta* in that it has the same apothecial pigmentation, ± identical-sized ascospores and, most importantly, an inspersed hymenium; however, it differs by containing xanthones (Nimis & Poelt 1987), including 2,5,7-trichloro-3-*O*-methylnorlichexanthone (our analyses). Similarly the saxicolous *L. patavina* (A. Massal.) Knoph & Leuckert also has an inspersed hymenium but differs chemically by containing atranorin and lichexanthone (Fletcher *et al.* 2009). Hence we concluded that the best outcome was to describe a new species.

Distribution and ecology: *Lecidella destituta* is an infrequently collected but almost certainly frequently overlooked species. It has been recorded from west of the Great Dividing Range in New South Wales, south-western Western Australia and from Kangaroo Island, South Australia. In Tasmania, herbarium collections

suggest it is quite rare, ranging from lowland to subalpine altitudes and colonising twigs and small branches of shrubs and young trees in open eucalypt-dominated woodland. Associated species include *Buellia dissa* (Stirt.) Zahlbr., *Caloplaca wilsonii* S.Y.Kondr. & Kärnefelt, *Menegazzia subpertusa* P. James & D.J. Galloway, *Pertusaria pertractata* Stirt., *Usnea inermis* Motyka and various crustose lichens.

Specimens examined: **TASMANIA.** Trevallyn State Recreation Area, 41°27'S 147°06'E, 200 m alt., 22.viii.1992, *A.V. Ratkowsky* s.n. (HO); Johnsons Lagoon, 41°59'S 146°23'E, 1040 m alt., 9.xii.2007, *G. Kantvilas 399/07* (HO); Derwent River above New Norfolk, 42°44'S 146°55'E, 40 m alt., 28.ix.2000, *G. Kantvilas 382/00* (HO); Pelion Plains, *c.* 0.5 km E of New Pelion Hut, 41°50'S 146°03'E, 850 m alt., 13.iii.1992, *G. Kantvilas 145/92* (HO). **NEW SOUTH WALES.** Ingalba Nature Reserve, 9 km W of Temora, 34°26'11"S 146°26'01"E, 315 m alt., 16.iv.2009, *J.A. Elix 39732* (CANB); Lachlan Range State Forest, 15 km NW of Rankins Springs, 33°47'S 146°07'E, 260 m alt., 12.vi.1990, *H.Streimann 44806* (CANB). **SOUTH AUSTRALIA.** KANGAROO ISLAND, Corner of Playford Hwy, Birchmore Hwy and road to Kingscote aerodrome, 35°42'S 137°31'E, 1982, *K. Stove 1789 p.p.* (AD); Weir Cove, 2 km E of Cape de Couedic, 36°03'S 136°43'E, 40 m alt., 28.ix.1994, *H. Streimann 54981* (CANB, HO); 3 km E of Seal Bay, 36°00'S 137°21'E, 30 m alt., 25.x.1985, *J.A. Elix 19589 & L.H. Elix* (CANB, HO); West Bay, 35°53'S 136°33'E, 10 m alt., 27.ix.2011, *G. Kantvilas 297/11* (AD, HO). **WESTERN AUSTRALIA.** Dally

Key to the Tasmanian species of *Lecidella*

1 Growing on rock or on bryophytes overgrowing rock 2
1: Growing on bark or wood 4

2 Hypothecium colourless or at most pale yellowish brown at the base 3
2: Hypothecium yellow-brown to dark brown, with the colour intensifying in K and N ..... 7. ***L. sublapicida***

3 Thallus granular, containing xanthones (K–, C+ orange); apothecia to 0.6 mm wide; colonising siliceous rocks ..... 4. ***L. granulosula***
3: Thallus rimose-areolate to rather lumpy and verruculose, containing atranorin and zeorin (K+ yellowish, C–); apothecia to 1.5 mm wide; mostly on calcareous substrata ..... 6. ***L. stigmatea***

4 Thallus not sorediate 5
4: Thallus sorediate 8

5 Thallus containing xanthones (C+ orange); hymenium not inspersed, or at most with an epihymenial layer of granules that dissolve in K 6
5: Thallus containing atranorin only (C–); hymenium inspersed with oil droplets and crystals that do not dissolve in K ..... 1. ***L. destituta***

6 Hypothecium pale yellow-brown to yellow-orange, colour intensifying in K; apices of paraphyses unpigmented or with an *external* cap of blue-green, N+ crimson pigment 7
6: Hypothecium colourless to pale brownish; apices of paraphyses with an *internal* cap of pigment ..... 8. ***L. xylogena***

7 Ascospores 15–24 × 8–13 µm; excipulum in section mainly opaque brown, with blue-green, N+ crimson pigment at the edges ..... 5. ***L. montana***
7: Ascospores 9–15 × 5–8 µm; excipulum in section mainly colourless to dilute brown, with blue-green, N+ crimson pigment at the edges ..... 2. ***L. elaeochroma***

8 Ascospores 12–18 × 6–10 µm; apices of paraphyses unpigmented or with an *external* cap of blue-green, N+ crimson pigment; excipulum in section opaque dark brown, lacking blue-green pigment; soredia arising in discrete soralia ..... 3. ***L. flavovirens***
8: Ascospores 7–14 × 4.5–9 µm; apices of paraphyses with an *internal* cap of pigment; excipulum in section grey-green to pale brownish, usually with blue-green pigment towards the outer edge; soredia not in discrete soralia, arising from a dissolution of the thallus ..... 8. ***L. xylogena***

(Dalwallinu) North Road, 14 km SE of Wubin, 30°13'40"S 116°44'50"E, 305 m alt., 30.iv.2004, *J.A. Elix 33568* (CANB).

2. *Lecidella elaeochroma* (Ach.) Hazsl.

Magy Birod. Zuzmo-Flor.: 197 (1884); *Lecidea parasema* β *elaeochroma* Ach., *Methodus*: 35: (1803).

Thallus smooth, rimose-areolate to papillate, pale grey to cream-grey, often rather discontinuous and revealing a thin, blue-black prothallus beneath, esorediate, forming irregular, extensive, undelimited patches typically along twigs and small branches. *Apothecia* 0.2–0.8 mm wide, sessile, basally constricted; disc plane at first, later often becoming convex, typically black, but rarely also pale to dark brown or mottled, matt to glossy, epruinose. *Proper excipulum* black, glossy, mostly persistent but sometimes ± excluded in the most convex apothecia, entire, in section 20–50 µm thick, colourless to dilute reddish brown within, unchanged in K, N+ intensifying orange-brown, mostly with additional blue-green, N+ crimson pigment, especially at the upper and outer edges. *Hypothecium* 50–90 µm thick, pale yellow-brown to yellow-orange, intensifying yellow-orange in K and N. *Hymenium* 50–90 µm thick, separating easily in K, mostly not inspersed, in the upper part intensely to dilutely greenish blue, K ± grey-green, N+ crimson, towards the base mostly colourless, typically overlain by a layer of brownish granules to c. 5–10 µm thick that dissolve in K. *Asci* 40–60 × 12–18 µm. *Paraphyses* 1.5–2.5 µm thick, simple; apices usually expanded to 2–4 µm thick, mostly with an external, blue-green, N+ crimson cap but sometimes unpigmented. *Ascospores* broadly ellipsoid, (9–)10–*12.1*–14(–15) × (5–)5.5–*6.4*–7.5(–8) µm. *Conidiomata* not observed. Fig. 1B

Chemical composition: As discussed by Knoph and Schmidt (1995) and Knoph and Leuckert (2004), this widespread species contains a complex range of xanthones. Material from mainland Australia and Tasmania revealed 2,5,7-trichloro-3-*O*-methylnorlichexanthone (major) together with arthothelin (±), isoarthothelin (±) atranorin (±), 5,7-dichloro-3-*O*-methylnorlichexanthone (±), 2,5-dichlorononorlichexanthone (±), 4,5-dichlorononorlichexanthone (±), 2,4-dichlorononorlichexanthone (±), 4,5-dichloro-3-*O*-methylnorlichexanthone (±) and thuringone (±); thallus K–, KC–, C+ orange, P–, UV± weak orange.

Remarks: This distinctive species is recognised by the combination of the esorediate thallus containing xanthones, the presence of blue-green pigment in the excipulum and hymenium, the yellow-orange, K+ intensifying hypothecium, the hymenium that is very lax in KOH, and the relatively small ascospores. Australian material concurs well with a wide a range of specimens from the Northern Hemisphere that were examined, as well as with published descriptions (Knoph & Leuckert 2004; Fletcher *et al.* 2009). However, unlike European specimens, the apices of the paraphyses of Australian specimens are almost always pigmented.

There are two additional species recognised in this account which have previously been included in a broad and very loosely defined concept of *Lecidella elaeochroma*. In drier, sclerophyll forests, there is *L. destituta*, which differs chiefly by containing atranorin only and having an inspersed hymenium. In highland areas of Tasmania, in habitats similar to those where *L. elaeochroma* might occur, there is *L. montana*, which differs by having larger ascospores and a persistent, opaque brown excipulum, and typically contains thiophanic acid and arthothelin.

Distribution and ecology: This very widespread, ± cosmopolitan species is very localised in Tasmania, where it is known from only a few collections, all from high, cold elevations, especially in relatively low-rainfall areas. Significantly, all specimens studied, even those from mainland Australia, grew on the twigs of the low, highly branched shrub, *Hymenanthera dentata* R.Br. ex DC. (Violaceae), where it forms a very extensive cover, colonising seemingly every centimetre of the small twigs and branchlets. Although in most cases it forms pure colonies, in one Tasmanian specimen it was associated with *Teloschistes velifer* F.Wilson, *Ramalina glaucescens* Kremp. and a tiny species of *Caloplaca*. In contrast, in the Northern Hemisphere, *L. elaeochroma* appears to be a widespread and broadly ecologically tolerant species found in woodland, heathland and on wayside trees.

Specimens examined: **TASMANIA.** Summit of Mount Wellington, 42°54'S 147°14'E, 1200 m alt., 9.i.1989, *M. Allen s.n.* (HO); Jacks Creek, 2 km NW of Lagoon of Islands, 42°04'S 146°54'E, 880 m alt., 27.ii.1984, *A. Moscal 6538 p.p.* (HO); Mt Ossa summit, 41°52'S 146°02'E, 1600 m alt., 14.iii.1992, *G.*

Kantvilas 116/92 (HO); unnamed quartzite summit E of Mt Eliza, 42°57'S 146°25'E, 1300 m alt., 21.i.2012, *G. Kantvilas 9/12* (HO). **VICTORIA.** Dargo High Plains, 37°06'S 147°09'E, 1620 m alt., 17.xii.1993, *H. Streimann 53196* (CANB, HO, MEL). **NEW SOUTH WALES.** Johnnies Plain, 36°26'S 148°21'E, 1750 m alt., 2.xii.1992, *G. Kantvilas 442/92 & J.A. Elix* (HO). **AUSTRALIAN CAPITAL TERRITORY.** Mt Clear, 35°53'S 158°05'E, 1590 m alt., 1.x.1980, *H. Streimann 10589* (*H. Hertel: Lecid. Exsicc.* nr. 150) (HO).

3. *Lecidella flavovirens* Kantvilas & Elix, *sp. nov.*

MycoBank No.: MB803600

Lecidellae xylogenae *similis sed acidum thiophanicum continenti, sorediis primum in soraliis discretis, 0.2–0.5 mm latis enatis, excipulo atrofusco, pigmentum aeruginosum destituto et ascosporis grandioribus, 12–18 µm longis, 6–10 µm latis differt.*

Type: **TASMANIA.** Ship Stern Bluff, 43°12'S 147°45'E, 80 m alt., on *Banksia marginata* in coastal scrub, 2 May 2011, *G. Kantvilas 185/11* (HO: holotype; BM, CANB: isotypes).

Thallus effuse, scurfy, pale grey, undelimited, lacking a prothallus, sorediate; soredia yellowish or greenish yellow, at first arising in discrete, roundish soralia c. 0.2–0.5 mm wide or, more rarely, irregularly in cracks in the thallus, soon spreading and coalescing, and the whole thallus becoming a rather thick, cracked sorediate mass, spreading in irregular, undelimited patches to 10 cm wide; soredia coarsely granular, with individual grains 20–30 µm wide. *Apothecia* 0.3–1 mm wide, sessile, basally constricted to rather adnate and nestling deeply amongst the soredia; disc plane or occasionally becoming convex, black, matt to glossy, epruinose. *Proper excipulum* concolorous with the disc, black, glossy, persistent, entire or occasionally flexuose, in section 30–60 µm thick, ± opaque dark brown, unchanged in K, N+ intensifying orange-brown, lacking blue-green pigments. *Hypothecium* 50–80 µm thick, colourless to pale yellow-brown, occasionally yellowish orange, more intensely coloured towards the base, intensifying yellow-orange in K and N. *Hymenium* 50–80 µm thick, in the upper part intensely to dilutely greenish blue, K± grey-green, N+ crimson, towards the base mostly colourless, not inspersed or overlain by granules, remaining rather coherent in K. *Asci* 45–55 × 15–24 µm. *Paraphyses* (1–)1.5 µm thick, simple; apices not markedly capitate, sometimes expanded to 2.5–4 µm, unpigmented or coated with blue-green, N+ crimson pigment. *Ascospores* (12–)13–*15.2*–17(–18) × (6–)7–*8.3*–10 µm, broadly ellipsoid, sometimes a little apiculate at one or both apices. *Conidiomata* not observed. Fig. 1C

Chemical composition: thiophanic acid (major), 4,5-dichloronorlichexanthone (± minor), asemone (± minor), isoarthothelin (± trace), arthothelin (± trace), argopsin (± minor), 5,7-dichloronorlichexanthone (± trace), atranorin (± minor), norlichexanthone (±); thallus K–, C+ orange, KC–, P–, UV+ orange. The array of compounds, especially xanthones, can be quite complex but thiophanic acid is invariably present.

Remarks: This is a very distinctive species on account of its rather bright, eye-catching, yellowish to yellowish green sorediate thallus. It is commonly encountered as sterile thalli only, although fertile specimens are not infrequent. Whilst the nature and disposition of the apothecial pigmentation (blue-green in the hymenium, brown in the excipulum, yellow-brown in the hypothecium) is constant, their intensity is highly variable. Specimens from exposed microhabitats have very intensely pigmented apothecia, whereas those from shaded, moist sites can be very dilutely coloured.

Lecidella flavovirens has some superficial similarities to *L. xylogena*, which often has a similar, yellowish sorediate thallus. However, that species appears much finer, but this impression is due not to a difference in size of the soredia (these are ± the same in both taxa) but due to the soredia being very thick and agglomerated in *L. flavovirens* but rather thinly dispersed in *L. xylogena*. There are further, more fundamental differences between the two species. Unlike *L. xylogena*, *L. flavovirens* lacks blue-green pigment in the excipulum. In *L. flavovirens*, pigment occurs on the outside of the paraphyses (not as an internal cap), and it is probably due to this that they remain more conglutinated in KOH. The two species also differ in that *L. xylogena* has smaller ascospores and contains thiophaninic acid. Indeed *L. flavovirens* is probably most similar to the chiefly Northern Hemisphere taxon, *L. scabra* (Taylor) Hertel & Leuckert, which has a similar gross morphology, displays a similar disposition of apothecial pigments, has similar-sized ascospores but differs chemically in containing atranorin and arthothelin (Knoph 1990), plus additional xanthones (our analyses).

Distribution and ecology: *Lecidella flavovirens* is a common and widespread species, recorded from Tasmania, Victoria, New South Wales, the Australian Capital Territory, South Australia (Kangaroo Island) and south-western Western Australia. In Tasmania, it is most commonly seen in coastal scrub and woodland, especially on *Banksia marginata* Cav., where it forms an extensive cover on trunks, young branches and twigs. It is also found in open, dry sclerophyll, eucalypt-dominated communities where it colonises logs, the bases of eucalypts, and the bark of understorey trees such as *Allocasuarina*. In such habitats, it is commonly associated with *Austroparmelina pseudorelicina* (Jatta) A.Crespo *et al.*, *Flavoparmelia rutidota* (Hook.f. & Taylor) Hale, *Pertusaria pertractata* Stirt., *P. trimera* (Müll.Arg.) A.W.Archer, *Tephromela atra* (Huds.) Hafellner, *T. sorediata* Kalb & Elix and *Usnea inermis* Motyka, as well as with its relative, *L. xylogena*. However, unlike that species, *L. flavovirens* has a broader ecological amplitude, extending into wet forests where it colonises understorey trees. In such habitats, associated lichens include *Mycoblastus campbellianus* (Nyl.) Zahlbr., *M. coniophorus* (Elix & A.W.Archer) Kantvilas & Elix and *Thelotrema lepadimum* (Ach.) Ach.

Selected specimens examined: **TASMANIA.** Coles Bay Conservation Area, 42°06'S 148°15'E, 50 m alt., 17.vi.2007, *G. Kantvilas 255/07* (HO); W of Tahune Bridge in the Warra SST, 43°06'S 146°41'E, 26.v.2008, *G. Kantvilas 209/08* (HO); N of Paradise Gorge, 42°33'S 147°50'E, 180 m alt., 12.vii.2009, *G. Kantvilas 291/09* (HO); *c.* 7 km E of Lake Leake, 42°01'30"S 147°55'00"E, 400 m alt., 24.iv.1996, *G. Kantvilas s.n.* (HO); South Sister, 41°32'S 148°10'E, 750 m alt., 11.xi.2004, *G. Kantvilas 283/04* (CANB, HO); Henty Sand Dunes, 42°04'S 145°17'E, 40 m alt., 21.i.2000, *G. Kantvilas 42/00* (HO); Fishers Point, 43°35'S 146°55'E, 1 m alt., 17.i.2004, *G. Kantvilas 77/04* (HO); Meredith Range, *c.* 3.5 km SE of Mt Meredith, 41°35'S 145°17'E, 750 m alt., 2.ii.2011, *G. Kantvilas 22/11* (HO); Levendale, 360 m alt., 1.viii.1981, *G. Kantvilas 440/81* (BM, HO); 1 km NW of Cockle Bay Lagoon, 42°42'S 147°56'E, 50 m alt., 24.vii.2011, *G. Kantvilas 222/11* (HO). **NEW SOUTH WALES.** Bermagui Trig Station, 36°25'S 150°05'E, 15 m alt., 14.vi.2006, *J.A. Elix 36604* (CANB); Goonoo State Forest, Mogriguy Forest Road, S km E of Mogriguy, 23 km NNE of Dubbo, 32°04'16"S 148°42'53"E, 330 m alt., 11.x.2005, *J.A. Elix 36776* (CANB); Bago Bluff National Park, Scrub Road, 7 km W of Wauchope, 31°28'45"S 152°39'36"E, 25 m alt., 8.viii.2008, *J.A. Elix 43275* (CANB). **VICTORIA.** Errinundra National Park, Goonmirk Rocks Road, 20 km SE of Bonang, 37°16'29"S 148°53'06"E, 910 m alt., 16.iv.2008, *J.A. Elix 39865* (CANB). **AUSTRALIAN CAPITAL TERRITORY.** Brindabella Range, N of summit of Mt Coree, 31 km W of Canberra, 35°18'S 148°49'E, 1400 m alt., 18.xii.1985, *J.A. Elix 19802B* (CANB). **SOUTH AUSTRALIA.** KANGAROO ISLAND, Creek Bay Farm, headwaters of Lubra Creek, 35°49'S 138°06'E, 40 m alt., 19.ix.2011, *G. Kantvilas 374/11, 377/11* (AD, HO). **WESTERN AUSTRALIA.** The Cascades, 4 km S of Pemberton, 34°29'S 116°02'E, 180 m alt., 13.ix.1994, *J.A. Elix 28929* (CANB); Drovers Cave National Park, Jurien Road, 6 km NE of Jurien Bay, 30°15'44"S 115°06'43"E, 42 m alt., 6.v.2004, *J.A. Elix 28928* (CANB); Badgingarra National Park, Bibby Road, Drummond Reserve, 30°29'15"S 115°26'07"E, 200 m alt., 6.v.2004, *J.A. Elix 28947* (CANB); Burma Road Flora Reserve, 14 km SE of Walkaway-Nangetty Road, 28°59'26"S 115°03'35"E, 200 m alt., 4.v.2004, *J.A. Elix 33770* (CANB); Caves Road near Mammoth Cave turnoff, 34°05'S 115°02'E, 9.x.1992, *G. Kantvilas 311/92* & *J. Jarman* (HO, PERTH).

4. *Lecidella granulosula* (Nyl.) Knoph & Leuckert

Herzogia 14: 9 (2000); *Lecidea granulosula* Nyl., in Cromb., *J. Bot.* 14: 21 (1876).

Thallus granular, continuous or in part dispersed, pale cream to yellowish grey, undelimited, lacking a prothallus, esorediate, forming patches to c. 10 cm wide. *Apothecia* 0.3–0.6 mm wide, sessile, basally constricted, scattered; disc persistently plane or becoming convex with age, black, matt, epruinose. *Proper excipulum* black, matt to glossy, entire, usually becoming rather obscure in the most convex apothecia, in section 25–40 µm thick, pale brown to brown within, intensifying in N, mostly together with blue-green, N+ crimson pigment that becomes more intense at the outer edge. *Hypothecium* 60–100 µm thick, colourless, becoming slightly yellowish in K. *Hymenium* 50–70 µm thick, separating easily in K, not inspersed, in the upper part dilutely to intensely blue-green, K± grey-green, N+ crimson, with or without epihymenial granules that dissolve in K. *Asci* 40–55 × 12–18 µm. *Paraphyses* 1–2 µm thick, simple or occasionally bifurcate near the apices; apices mostly expanded, with an external, blue-green, N+ crimson cap 3–5 µm wide. *Ascospores* broadly ellipsoid to rather oblong, (9–)10–*11.5*–14 × (4.5–)5–*6.1*–7(–8) µm. *Conidiomata* not seen. Fig. 1D

Chemical composition: chodatin, demethylchodatin, thiophanic acid, 2,5,7-trichloro-3-*O*-methylnorlichexanthone (minor), thiophaninic acid (± minor), isoarthothelin (± minor), 2,4-dichloronorlichexanthone (± trace), 2,5,7-trichlorolichexanthone (± minor), 5,7-dichloro-3-*O*-methylnorlichexanthone (± trace), isoarthothelin (± minor); thallus K–, C+ orange, KC–, P–, UV+ orange.

Remarks: This species is readily recognised by the combination of the saxicolous habit, the finely granular thallus, the rather small apothecia and the colourless hypothecium (see also Knoph & Leuckert 2004). The morphology of the thallus can resemble that of *Lecidella sublapicida*, but that species has a yellow-brown to reddish brown hypothecium and differs chemically in containing vicanicin in addition to a suite of xanthones;

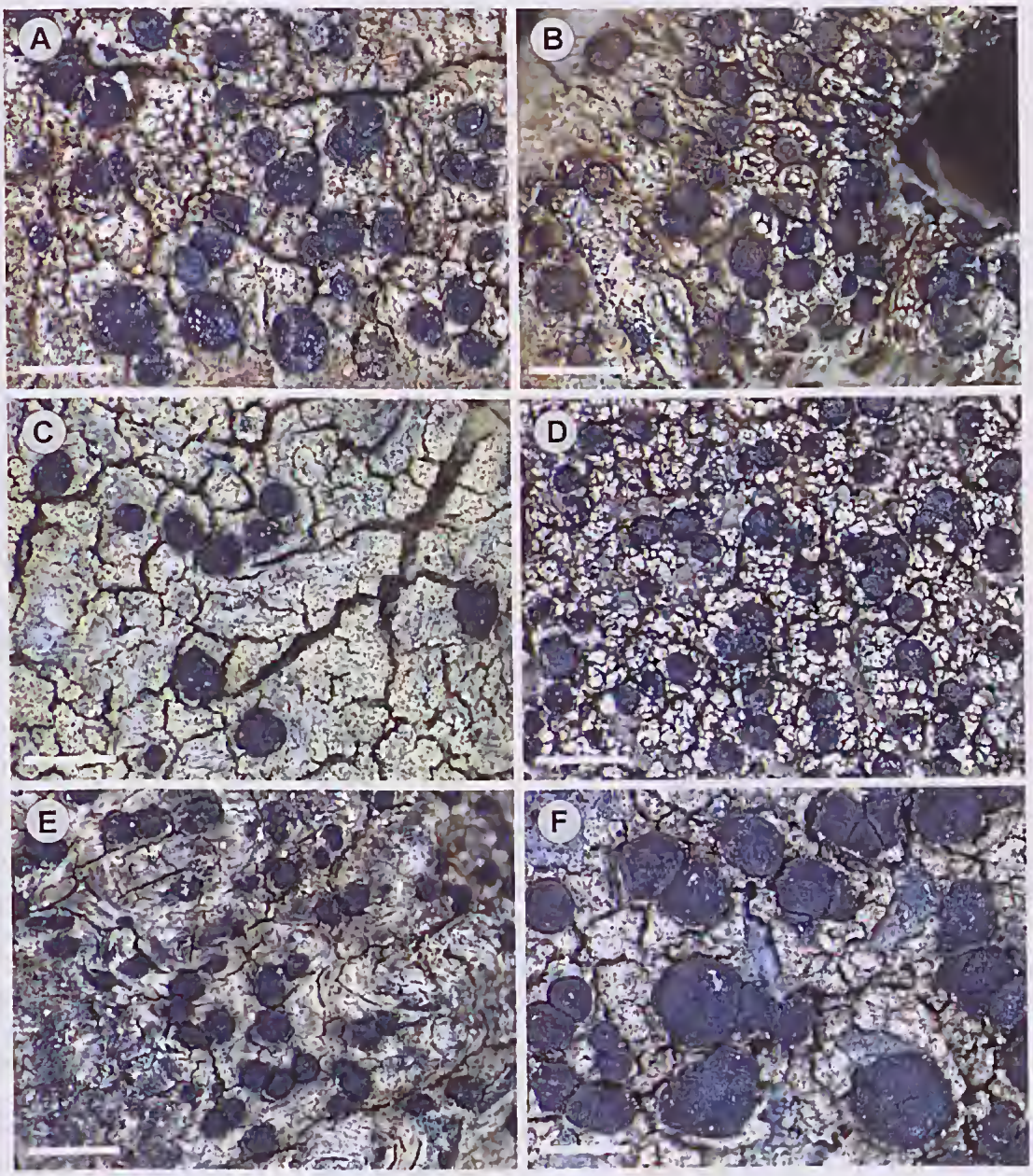

Figure 1. Habit of *Lecidella* species. **A.** *L. destituta* (holotype); **B.** *L. elaeochroma (Kantvilas 116/92)*; **C.** *L. flavovirens* (holotype); **D.** *L. granulosula (Elix 28764 & Kantvilas)*; **E.** *L. montana (Kantvilas 142/00)*; **F.** *L. stigmatea (Kantvilas 168/98)*. Scale = 1 mm.

furthermore the thallus of *L. sublapicida*, although often rather granular and warty, is much coarser. Of the species studied, *L. stigmatea* is the only other saxicolous species that has a colourless hypothecium, but it differs from *L. granulosula* by having much larger apothecia, a thicker thallus containing atranorin and zeorin, and a predominantly brown to purple-brown epihymenium.

Distribution and ecology: This species is widespread in both hemispheres and in Australia has previously been recorded from New South Wales (Knoph 1990; Knoph & Leuckert 2000) and Tasmania (Elix 2006). It appears to be quite uncommon (or overlooked). In Tasmania, it was recorded from rocks in rough pasture in a very low rainfall (c. 500 mm per annum) area, where it was associated with species of *Xanthoparmelia*, *Acarospora* and other crustose lichens. On Kangaroo Island, it was collected from eutrophicated coastal rocks in a penguin colony.

Specimens examined: **TASMANIA.** Lower Marshes Road, c. 1 km SW of Northumbria Hill, 42°23'S 147°15'E, 450 m alt., 9.xi.2004, *J.A. Elix 28764 & G. Kantvilas* (HO); Clarke Island, 40°30'S 148°10'E, 186 m alt., 1.iv.1980, *J.S. Whinray 1466* (HO, MEL). **NEW SOUTH WALES.** Goonoo State Forest, Cashels Dam Road, 31 km SE of Gilgandra, 31°55'57"S 148°52'17"E, 390 m alt., 12.x.2005, *J.A. Elix 37979* (CANB); Gibraltar Range State Forest, 49 km E of Glen Innes, 29°36'17"S 152°10'34"E, 1020 m alt., 2.v.2005, *J.A. Elix 39406* (CANB). **SOUTH AUSTRALIA.** KANGAROO ISLAND, Northern end of Antechamber Bay, 35°47'S 138°04'E, 5 m alt., 19.ix.2011, *G. Kantvilas 399/11* (HO).

5. *Lecidella montana* Kantvilas & Elix, *sp. nov.*

MycoBank No.: MB803598

Lecidellae elaeochromae commonita sed hymenio potius cohaerenti, ascosporis magnioribus, 15–24 µm longis, 8–13 µm latis, et acidum thiophanicum continenti differt.

Type: **AUSTRALIA, TASMANIA.** Falling Mountain, 41°55'S 146°06'E, 1480 m alt., on twigs of *Diselma archeri* in alpine heathland, 11 March 2011, *G. Kantvilas 137/11* (holotype: HO).

Thallus mostly rather patchy and discontinuous, revealing a thin blue-black prothallus beneath, effuse, smooth to rimose-areolate, rarely a little papillate, pale yellowish grey to cream-grey, esorediate, forming irregular, undelimited patches, sometimes to 10 cm wide but typically much smaller. *Apothecia* 0.2–0.7 mm wide, sessile, basally constricted; disc plane or occasionally becoming convex, black, matt to glossy, very rarely brown to dark brown, epruinose. *Proper excipulum* black, glossy, persistent, entire or occasionally flexuose or crenulate, in section 30–50 µm thick, pale to opaque dark brown within, unchanged in K, N+ intensifying orange-brown, sometimes also with blue-green, N+ crimson pigment at the inner edge. *Hypothecium* 30–100 µm thick, pale yellow-brown to yellow-orange, more intensely coloured towards the base, intensifying yellow-orange in K and N. *Hymenium* 70–100 µm thick, not inspersed, remaining rather coherent in K, in the upper part intensely to dilutely greenish blue, K± grey-green, N+ crimson, towards the base mostly colourless, commonly overlain by a layer of brownish granules to c. 10 µm thick that dissolve in K. *Asci* 55–70 ×18–30 µm. *Paraphyses* 1.5–2 µm thick, simple or with occasional branches and anastomoses; apices usually expanded to 2.5–5 µm thick, usually coated with blue-green, N+ crimson pigment. *Ascospores* 15–*18.1*–22(–24) × 8–*10.3*–12(–13) µm, broadly ellipsoid, frequently discoloured pale olive-brown. *Conidiomata* not observed. Fig. 1E

Chemical composition: thiophanic acid (major), isoarthothelin (± minor), 2,5,7-trichloro-3-*O*-methylnorlichexanthone (±), asemone (± trace); thallus K–, C+ orange, KC–, P–, UV+ orange.

Remarks: With its abundant black apothecia, pale yellowish-tinged, xanthone-containing thallus and predominantly twig habitat, this species is superficially similar to *Lecidella elaeochroma*. Like that species, it also has a K+ yellow-orange intensifying hypothecium and a granular epihymenium. It differs chiefly by its incrementally larger ascospores: in *L. elaeochroma* these are not known to exceed 17 µm in length, whereas in *L. montana* they are seldom shorter than that. Additional distinguishing features of *L. montana* include the relatively coherent hymenium in KOH, and the excipulum which is typically opaque brown in section and largely lacks blue-green pigment. Furthermore, the excipulum in the new species tends to be persistent, whereas in *L. elaeochroma* it is eventually excluded as the apothecia become very convex. The intensity of apothecial pigmentation appears to be linked to the degree of exposure. In extreme shade, such as within a dense shrub, the apothecia can have a brownish disc. In exposed habitats, the apothecia are jet black,

and the blue-green pigment saturates the hymenium and clothes the upper parts of the paraphyses. The thallus varies from being almost absent, to consisting of rather dispersed, pale areoles, to being darker and ± continuous; again this variation is attributed to habitat factors.

The generic placement of this new species remains somewhat uncertain. The combination of its gross morphology, general pigmentation of the apothecia, structure of the excipulum and thallus chemistry are all consistent with *Lecidella*. However, the coherent hymenium is not, and the asci, although mostly of the *Lecidella*-type, may also tend towards the *Lecanora*-type, where the *masse axiale* penetrates the tholus ± entirely. However, at this point, there appears to be no better taxonomic placement for this lichen. The genus *Carbonea* was considered, but to place this epiphytic species into an essentially saxicolous genus seems inappropriate.

Distribution and ecology: This species is common and widespread in highland areas in Tasmania, where it is found on living and dead twigs and small branches of various trees and shrubs in heathland and woodland, for example, species of *Orites* R.Br., *Microstrobos niphophilus* J.Garden & L.Johnson, *Diselma archeri* Hook.f., *Nothofagus cunninghamii* (Hook.) Oersted and *Epacris serpyllifolia* R.Br. It is commonly the dominant lichen in such habitats, clothing the entire length of the substrate and consequently occurs in pure colonies rather than in association with other lichens. It also colonises the fibrous bark of the trunks of the conifer *Athrotaxis cupressoides* D.Don. It is typically quite conspicuous, with its abundant black apothecia contrasting with the pale colour of the bleached twigs on which it grows.

Specimens examined: **TASMANIA.** Lake Skinner, 42°S6'S 146°41'E, 970 m alt., 17.v.2008, *G. Kantvilas 200/08* (HO); summit of Rodway Range, 42°41'S 146°34'E, 1375 m alt., 17.iv.2006, *G. Kantvilas 206/06* (HO); foot of Adam Peak, 41°44'S 146°41'E, 1210 m alt., 24.i.2009, *G. Kantvilas 3/09* (HO); Blue Peaks, northern summit, 41°43'S 146°22'E, 1340 m alt., 20.xi.2006 (HO), *G. Kantvilas 526/06* (HO); Lake Esperance, 43°14'S 146°46'E, 980 m alt., 30.xii.1999, *G. Kantvilas 461/99* (HO); Meredith Range, c. 3.5 km SE of Mt Meredith, 41°35'S 145°17'E, 750 m alt., 2.ii.2011, *G. Kantvilas 27/11* (HO); near the summit of Black Bluff, 41°27'S 145°57'E, 1300 m alt., 26.iii.2000, *G. Kantvilas 142/00* (HO); southern summit of Mt Wright, 42°37'S 146°20'E, 1110 m alt., 26.i.2008, *G. Kantvilas 31/08* (HO); Mt Sprent, 42°48'S 145°58'E, 900 m alt., 17.ii.1987, *G. Kantvilas 73/87* (HO, M); Little Horn, 41°41'S 145°58'E, 1320 m alt., 16.ix.1995, *G. Kantvilas 90/95* (HO); summit of Clear Hill, 42°41'S 146°16'E, 1198 m alt., 27.xii.2011, *G. Kantvilas 499/11* (HO); Turrana Bluff, 41°46'5 146°21'E, 1450 m alt., 16.ii.2012, *G. Kantvilas 50/12* (HO).

6. *Lecidella stigmatea* (Ach.) Hertel & Leuckert

Willdenowia 5: 375 (1969); *Lecidea stigmatea* Ach., *Lich. Univ.*: 161 (1810).

Thallus rimose-areolate to rather lumpy and verruculose, continuous or dispersed, pale cream- to grey-brown, sometimes discoloured brownish, undelimited, lacking a prothallus, esorediate, forming extensive patches to c. 20–30 cm wide. *Apothecia* 0.4–1.5 mm wide, sessile, basally constricted, scattered or crowded together; disc plane, becoming undulate to convex in the oldest, largest apothecia, black, matt, epruinose. *Proper excipulum* black, matt to glossy, mostly persistent although occasionally rather obscure in the most convex apothecia, entire, in section 35–*50*(–80) µm thick, blue-green, K± grey-green, N+ crimson at the outer edge, increasingly dilute blue-green to colourless within. *Hypothecium* 60–150 µm thick, colourless or occasionally pale yellow-brown at the base. *Hymenium* 60–100 µm thick, separating easily in K, not inspersed, in the upper part brownish to purple-brown, intensifying in K, typically also with at least some blue-green, N+ crimson pigment, towards the base mostly colourless, not overlain by epihymenial granules. *Asci* 45–60 × 13–20 µm. *Paraphyses* 1–2 µm thick, simple; apices unpigmented and not expanded or, more commonly, with an external, blue-green, N+ crimson cap 2.5–5 µm wide. *Ascospores* broadly ellipsoid to rather oblong, (10–) 11–*13.4*–15(–16) × (6–)6.5–*7.8*–9(–10) µm. *Conidiomata* rare, located in only one specimen, immersed; conidia thread-like, curved, c. 12–20 × 1 µm. Fig. 1F

Chemical composition: atranorin and zeorin; thallus K+ weakly yellow, KC–, C–, P–, UV–.

Remarks: This species is characterised by the relatively wide-spreading, well-developed thallus containing atranorin and zeorin (an unusual chemistry for the genus), the relatively large apothecia that become convex at maturity, and the often-massive, mainly colourless hypothecium (see also Knoph & Leuckert 2004; Fletcher *et al.* 2009). Of the saxicolous

species studied, *Lecidella stigmatea* shares a colourless hypothecium with *L. granulosula*, but that species differs by its granular thallus containing xanthones (C+ orange) and by its smaller apothecia. It differs starkly from *L. sublapicida*, which has a brownish hypothecium and also contains xanthones.

Distribution and ecology: *Lecidella stigmatea* is a very widespread species in both hemispheres, occurring mainly on calcareous substrates. Its Tasmanian distribution ranges from limestone outcrops in natural vegetation to concrete in a suburban garden. Several collections are also from dolerite, a siliceous rock type, in sites subject to nutrient enrichment, such as boulders in rough sheep-grazing land. Associated species include *Lecanora dispersa* (Pers.) Sommerf., *Candelariella aurella* (Hoffm.) Zahlbr., *C. vitellina* (Hoffm.) Müll.Arg. and species of *Caloplaca*. It was first reported for Tasmania by Hertel (1989).

Specimens examined: **TASMANIA.** Lune River Lagoon mouth, 43°26'S 146°55'E, 1968, *G.C. Bratt 68/523* (HO); Glen Morey Saltpan near Tunbridge, 42°09'S 147°29'E, 175 m alt., 1984, *A. Moscal 8793* (HO); Giblin River, *c.* 7 km SW of Hardwood Hill, 70 m alt., 1985, *G. Kantvilas 182/85* (HO); Cascades, Hobart, 42°54'S 147°17'E, 130 m alt., 1998, *G. Kantvilas 168/98* (HO); Bisdee Tier, 42°26'S 147°17'E, 640 m alt., 2009, *G. Kantvilas 171/09* (HO). **AUSTRALIAN CAPITAL TERRITORY.** Brindabella Range, summit of Mt Aggie, 35°28'S 148°46'E, 22.xi.1989, *W.H. Ewers 4610* (CANB).

7. *Lecidella sublapicida* (C. Knight) Hertel

Mitt. Bot. München 19: 444 (1983); *Lecidea sublapicida* C. Knight, *Trans. N.Z. Inst.* 8: 316 (1876).

Thallus rimose-areolate to rather granular-verruculose, continuous or dispersed, pale pinkish brown, cream-grey to grey-brown, undelimited, sometimes very thin to absent, lacking a prothallus, esorediate, forming irregular patches to c. 10 cm wide. *Apothecia* 0.2–0.8 mm wide, scattered or crowded together, sessile, basally constricted; disc mostly persistently plane, sometimes a little undulate but only rarely convex, black, matt to glossy, epruinose. *Proper excipulum* black, matt to glossy, entire to a little flexuose, mostly persistent or becoming inconspicuous and excluded, especially in more convex apothecia, in section 15–50 µm thick, opaque red-brown within, unchanged in K, N+ intensifying orange-brown, also with additional blue-green, N+ crimson pigment, particularly at the edges, rarely ± entirely deep blue-green. *Hypothecium* 20–100 µm thick, yellow-brown to deep brown, intensifying yellow-orange in K and N, typically subtended by a darker red-brown layer continuous with the excipulum. *Hymenium* 55–90 µm thick, separating easily in K, in the upper part intensely greenish blue, K± grey-green to blue-green, N+ crimson, towards the base mostly colourless, occasionally overlain by brownish granules that dissolve in K. *Asci* 40–60 × 12–20 µm. *Paraphyses* 1–2 µm thick, simple to sparsely branched; apices unpigmented and only slightly expanded to 2–2.5 µm wide or, more commonly, with an external, blue-green, N+ crimson cap 2–4 µm wide. *Ascospores* broadly ellipsoid to ovate, (9–)10–*12.3*–15(–17) × (4.5–)6–*6.9*–8(–9) µm. *Conidiomata* not observed. Fig. 2A

Chemical composition: vicanicin, 2,5,7-trichloro-3-*O*-methylnorlichexanthone, 5,7-dichloro-3-*O*-methylnorlichexanthone, isoarthothelin (minor), arthothelin (± minor), atranorin (± minor), vicanicin methyl ether (± minor), 5,7-dichlorolichexanthone (± minor), 3-*O*-methylasemone (± minor), 3-*O*-methylthiophanic acid (± minor), thiophanic acid (± minor), 2,5,7-trichlorolichexanthone (± minor); thallus K–, KC–, C+ orange, P–. The suite of xanthones present is highly variable and not easily detected by thin-layer chromatography; however, vicanicin is inevitably present. In specimens where the thallus is extremely thin to absent, thin-layer chromatography may not detect any substances.

Remarks: *Lecidella sublapicida* is recognised by its often rather granular thallus, and abundant, black, usually persistently marginate apothecia with a red-brown to yellow-brown hypothecium. Unlike in most other *Lecidella* species studied, the excipulum appears to be cupular or almost so, and extends continuously beneath the hymenial and subhypothecial layers, forming a secondary, deeper brown layer of tissue. Also characteristic is the presence of vicanicin together with a suite of xanthones. The dark hypothecium is unique to *Lecidella* in Tasmania and the presence of vicanicin is diagnostic.

This species is very closely related to the widespread, chiefly Northern Hemisphere taxon, *L. carpathica* Körb., which has an identical habitat ecology, a

virtually identical thallus morphology and apothecial anatomy, but differs chemically in containing diploicin (instead of vicanicin) and the xanthone thuringione (see also Knoph 1990). This subtle chemical difference requires high performance liquid chromatography for accurate determination. Although *L. carpathica* has been recorded for Tasmania, it appears to have been consistently mistaken for *L. sublapicida*, and all material studied has been determined by us as the latter.

Another anatomically similar species with a yellow-brown hypothecium and a granular-verrucose thallus containing xanthones is *L. wulfenii* (Hepp) Körb., which is widespread in the Northern Hemisphere where it grows over bryophytes and soil (Knoph & Leuckert 2004; Fletcher *et al.* 2009). It has also been recorded occasionally in the Southern Hemisphere: from New Zealand (Galloway 2007) and the Subantarctic islands (Øvstedal & Lewis Smith 2001). We originally contemplated including one unusual Tasmanian specimen (*Kantvilas 923/01*), collected from alpine bryophytes overgrowing a boulder, as this species. However, in addition to a suite of xanthones, this specimen also contains vicanicin, an unusual and diagnostic substance in *Lecidella*, and hence we have determined it as *L. sublapicida*.

Distribution and ecology: This is a very widespread, saxicolous species in the temperate Southern Hemisphere. In Tasmania, it displays a very wide ecological amplitude, ranging from the coast to the summits of the highest peaks. It is often found in nutrient-enriched habitats. For example, at alpine elevations it grows on large, bird-perch boulders where it is part of a rich lichen community that includes *Xanthoria candelaria* (L.) Th.Fr., *Candelariella vitellina* (Hoffm.) Müll.Arg., *Protoparmelia badia* (Hoffm.) Hafellner, *Xanthoparmelia loxodella* (Essl.) O.Blanco *et al.*, *Immersaria athroocarpa* (Ach.) Rambold & Pietschm, *Rimularia psephota* (Tuck.) Hertel & Rambold, *Usnea torulosa* (Müll.Arg.) Zahlbr., *Lecanora polytropa* (Ehrh.) Rabenh. and *L. rupicola* (L.) Zahlbr. It has also been recorded in areas of human-induced eutrophication, such as on rocks splashed by urine in the vicinity of bush-walkers huts. In such habitats, it may form extensive, pure colonies. In rough grazing land it occurs on boulders amongst grasses. On coastal rocks it can be found associated with species of *Xanthoparmelia* and *Caloplaca*. Although exclusively saxicolous, one specimen studied was from hardened gloss house paint. The unusual muscicolous specimen was from the moist, sheltered face of a large dolerite boulder in highland eucalypt woodland, where it was associated with *Teloschistes spinosus* (Hook.f. & Taylor) J.S.Murray, the basal squamules of *Cladonia* and incipient thalli of Parmeliaceae.

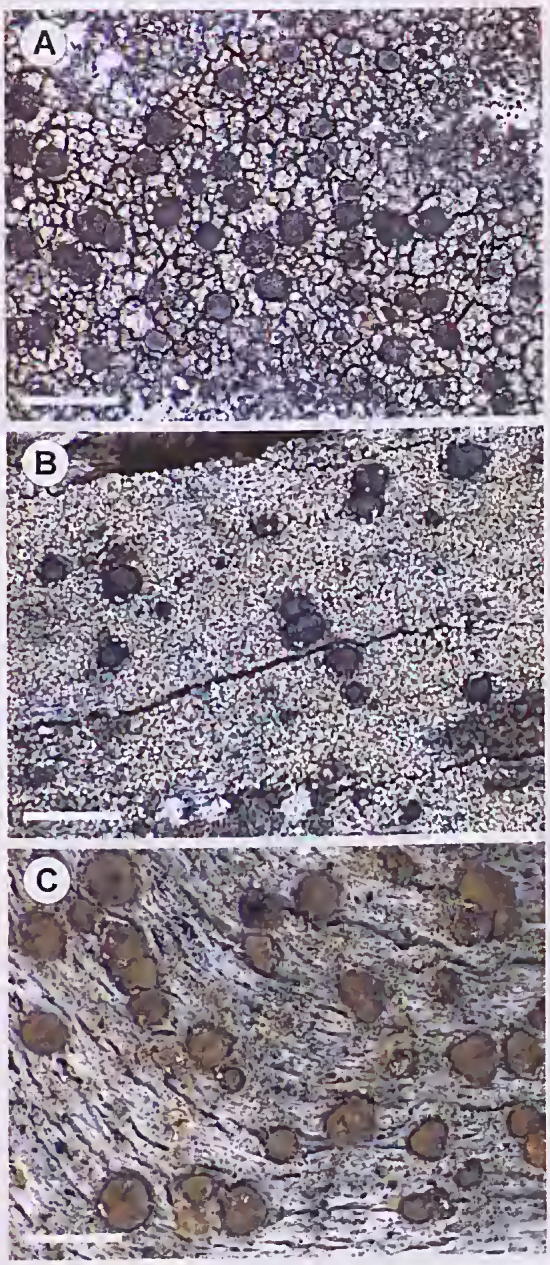

Figure 2. Habit of *Lecidella* species. **A.** *L. sublapicida (Kantvilas 570/00)*; **B.** *L. xylogena* with typical, farinose sorediate thallus and dark-pigmented apothecia (*Bastow s.n.*); **C.** *L. xylogena* with highly reduced, esorediate thallus and pallid apothecia (*Kantvilas 303/05*). Scale = 1 mm.

Specimens examined: **TASMANIA.** Mt King William I, 42°14'S 146°08'E, 1240 m alt., 31.i.1984, *G. Kantvilas 88/84B* (HO); Couta Rocks, 41°10'S 144°41'E, 9.xii.1993, *G. Kantvilas 304/93 & J. Elix* (HO); Huon Road, 42°54'S 147°17'E, 240 m alt., 30.xii.2000, *G. Kantvilas 570/00* (HO); near Temma, 41°13'S 144°42'E, 5 m alt., 21.xi.2001, *G. Kantvilas 1200/01* (HO); 5outh 5ister, 41°32'S 148°10'E, 750 m alt., 10.xi.2004, *G. Kantvilas 419/04* (HO); Mersey Crag, 41°46'S 146°20'E, 1420 m alt., 3.ii.2010, *G. Kantvilas 65/10* (HO); c. 2 km S of Lake Augusta, 41°54'S 146°E, 1140 m alt., 14.xii.1999, *G. Kantvilas 447/99* (HO); Lake Kaye, 41°54'5 146°31'E, 1140 m alt., 8.iii.2000, *G. Kantvilas 92/00* (HO); c. 8 km S of Beaconsfield, 41°14'S 146°52'E, 1984, *J. Jarman s.n.* (HO); Lake Newdegate, 42°40'S 146°34'E, 1090 m alt., 28.x.2007, *G. Kantvilas 328/07* (HO); Blue Peaks, northern summit, 41°43'S 146°22'E, 1350 m alt., 20.xi.2006, *G. Kantvilas 531/06* (HO); Bisdee Tier, 42°26'S 147°17'E, 640 m alt., 11.iii.2009, *G. Kantvilas 114/09* (HO); western slope of Table Mountain, 42°14'S 147°08'E, 1030 m alt., 6.x.2001, *G. Kantvilas 923/01* (HO); summit of Sandbanks Tier, 41°51'5 146°52'E, 1400 m alt., 24.vi.2000, *G. Kantvilas 332/00* (HO); Skullbone Plains, 42°02'S 146°19'E, 1000 m alt., 29.ii.2012, *G. Kantvilas 99/12* (HO). **VICTORIA.** Alpine National Park, Mt McKay, 16 km SSE of Mt Beauty township, 36°52'S 147°14'E, 1840 m alt., 18.ii.1994, *J.A. Elix 40605 & H. Streimann* (B, CANB); Alpine National Park, Pretty Valley, 18 km SSE of Mt Beauty township, 36°53'S 147°14'E, 1600 m alt., 18.ii.1994, *J.A. Elix 40622 & H.Streimann* (CANB). **SOUTH AUSTRALIA.** KANGAROO ISLAND, Northern end of Antechamber Bay, 35°47'S 138°04'E, 5 m alt., 19.ix.2011, *G. Kantvilas 401/11* (HO); Cape Willoughby Road, 35°50'S 138°06'E, 110 m alt., 29.ix.2011, *G. Kantvilas 325/11* (HO). **WESTERN AUSTRALIA.** Stirling Range National Park, summit of Toolbrunup Peak, 40 km SW of Borden, 34°23'S 118°03'E, 980 m alt., 17.ix.1994, *J.A. Elix 41522* (CANB, H, M).

8. *Lecidella xylogena* (Müll. Arg.) Kantvilas & Elix, *comb. nov.*

MycoBank No.: MB803601

Lecidea xylogena Müll. Arg., *Bull. Herb. Boissier* 1: 44 (1893).

Type: **VICTORIA.** On dead wood, 1892, *F.R.M. Wilson 1339* (holotype: G!; isotype: BM!).

Thallus scurfy or rarely composed of minute, dispersed areoles, sometimes ± absent or inapparent, pale grey to yellowish, occasionally ± esorediate, but more commonly soon dissolving ± entirely into a conspicuous, pale yellowish to greenish yellow sorediate mass, spreading in irregular, undelimited patches c. 10–30 mm wide; soredia farinose to coarsely granular, with individual grains 16–30 µm wide. *Apothecia* 0.3–0.7 mm wide, sessile, basally constricted to rather adnate, often nestling deeply amongst the soredia; disc plane to slightly concave, pale brownish to brown-grey, rarely dark grey to brownish black, rather waxy, typically epruinose but rarely with a thin, discontinuous, greyish pruina. *Proper excipulum* dark grey to black, more rarely pale to dark red-brown, rather glossy, persistent, entire or occasionally flexuose, in section 15–40 µm thick, grey-green to pale brownish within, usually more intensely pigmented greenish blue, N+ crimson towards the outer edge, more rarely entirely lacking pigment. *Hypothecium* 40–120 µm thick, colourless to pale brownish, unchanged or intensifying brownish yellow in K. *Hymenium* 50–70 µm thick, colourless, not inspersed, very lax and separating readily in K, overlain by an epithecium c. 10 µm thick consisting of brownish granules that dissolve in K and the grey-green apices of the paraphyses. *Asci* 40–55 × 13–20 µm. *Paraphyses* (1–)1.5(–2) µm thick, simple except for occasional bifurcations at the apices, markedly capitate; apices 3.5–5 µm wide, occasionally a little moniliform, with an internal cap of grey-green, N+ crimson pigment. *Ascospores* (7–)8–*10.9*–14 × 4–*6.3*–8(–9) µm, broadly ellipsoid. Conidiomata not observed. Figs 2B–C

Chemical composition: thiophaninic acid (major), thiophanic acid (± trace), 2,4-dichloronorlichexanthone (± trace), 2,5,7-trichloro-3-*O*-methylnorlichexanthone (±), asemone (± trace), isoarthothelin (± trace), isopigmentosin B (± trace), isopigmentosin C (± trace), usnic acid (± trace); thallus K–, C+ orange, KC–, P–, UV+ orange. The chemical composition of this species can be rather variable. Thiophaninic acid is the major compound in the great majority of specimens studied, including the type. Occasional specimens yielded no chemistry, but this is attributed to having attempted to extract too little thallus material. Two enigmatic specimens (*Kantvilas 131/06, 235/09*) lack thiophaninic acid but contain arthothelin as the major compound, whereas a third (*Ratkowsky s.n.*, HO 301660) contains only 2,5,7-trichloro-3-*O*-methylnorlichexanthone. Nevertheless, all display the distinctive and highly characteristic anatomical features of thiophaninic acid-containing specimens (see discussion below).

Remarks: This is a variable species morphologically and anatomically. The type specimen of *Lecidella*

xylogena has a yellowish, finely farinose sorediate thallus containing thiophaninic acid, relatively small apothecia with a pale disc and darker, thin persistent margin, a granular, brownish epithecium that dissolves in KOH, capitate, apically pigmented paraphyses that are very lax in KOH, and rather small ascospores. The majority of specimens studied display these features. The paraphyses in particular are highly distinctive: whereas in all the other species studied, any apical pigmentation occurs as an *external* cap, in *L. xylogena*, the pigmentation is entirely *within* the markedly expanded terminal cell. The soredia in *L. xylogena* do not arise from discrete soralia but are derived from a general disintegration of the thin, scurfy thallus. In some specimens, the thallus is ± absent whereas in others, soredia are barely developed and the thallus consists of tiny yellowish granules; in these instances, the anatomy of the apothecia determine the identity of the specimens. Very occasional specimens (or parts of specimens) have entirely pale to dark reddish brown apothecia that lack almost any trace of blue-green pigment; this is attributed to the degree of exposure of the microhabitat.

In exploring the chemical variation of this species, we looked for correlations between chemistry and anatomical/morphological characters but without success, and the more specimens or apothecial sections were examined, the more any suspected correlations, for example with ascospore size, became blurred. Specimens containing 2,S,7-trichloro-3-*O*-methylnorlichexanthone (instead of thiophaninic acid) were especially problematic. For these the name *Lecidea leptolomoides* Müll.Arg (syn. *L. minutula* Müll.Arg) could be available. The isotypes of these two taxa (in NSW) both have this chemistry and represent a *Lecidella* with a very thin, inconspicuous, esorediate thallus, collected from the bark of exotic trees in Victoria. Yet anatomically both specimens display all the key characters of *L. xylogena* with respect to ascospore size, paraphyses and excipular pigmentation. At this stage we are reluctant to formally synonymise these names, but we are nevertheless placing all specimens with the characters outlined above under the name *L. xylogena* regardless of thallus chemistry.

The most similar species to *L. xylogena* is *L. flavovirens*, which differs by having a much coarser, thicker, sorediate thallus in which the soredia initially arise in discrete soralia and then spread and coalesce, and has more intensely pigmented apothecia in which there is no brown, granular epithecium, and in which the blue-green pigment is confined to the upper part of the hymenium (and does not occur in the excipulum). *Lecidella flavovirens* differs further by having larger ascospores and by containing thiophanic acid as the major compound. Also somewhat similar is the Northern Hemisphere's *L. subviridis* Tønsberg, but this contains atranorin in addition to thiophanic acid and arthothelin (our analyses), and has larger ascospores (Fletcher *et al.* 2009).

Lecidella xylogena can also rarely be confused with *Ramboldia sorediata* Kalb in that both can have an entirely sorediate thallus and occur in the same habitats. The latter species typically has a whitish thallus, but it can occasionally become a little yellowish green. Such specimens are readily identified as *Ramboldia* by their chemistry (thamnolic acid, K+ yellow). Also similar is a rather common, yellowish, entirely sorediate, sterile lichen that occurs on old worked timber in gardens; it contains usnic acid as the major compound and is likely to be a species of *Lecanora*.

Distribution and ecology: *Lecidella xylogena* is a tiny species found mainly on the lignin or bark of eucalypts or on understorey trees such as *Allocasuarina* in dry sclerophyll woodlands, especially at low elevations. There it is part of a rich association of small, mainly lignicolous lichens, including *Buellia* spp., *Candelariella reflexa* (Nyl.) Lettau, *Lecanora subtecta* (Stirt.) Kantvilas & LaGreca, *Micarea* spp., *Pertusaria pertractata* Stirt., *Punctelia pseudocoralloidea* (Gyel.) Elix & Kantvilas, *Ramboldia sorediata* Kalb, *Rinodina asperata* (Shirley) Kantvilas and *Usnea inermis* Motyka. It has also been collected from split eucalypt fence posts in pasture land and from the bark of exotic trees such as *Prunus* species in cultivated gardens. Less commonly it occurs at alpine elevations on eucalypt wood and on the twigs of shrubs such as *Richea sprengelioides* (R.Br.) F. Muell. It has been recorded in eastern and northern Tasmania, Victoria, Kangaroo Island (South Australia) and the Australian Capital Territory, but can be expected to be widespread in low rainfall areas of southern Australia.

Selected specimens examined: **TASMANIA.** Launceston, Carr Villa Cemetery, 41°28'S 147°10'E, 80 m alt., 4.ii.1992, *A.V.*

Ratkawsky s.n. (HO); Trevallyn SRA, 41°27'S 147°06'E, 200 m alt., 22.viii.1992, *A.V. Rotkawsky s.n.* (HO); Cripps Creek, 43°08'S 147°43'E, 2 m alt., 5.x.1995, *L. Cove s.n.* (HO); Brawn Mountain Raad near garbage tip, 42°38'S 147°28'E, 160 m alt., 18.ix.2002, *G. Kantvilos 501/02* (HO); Mayfield Paint, 42°15'S 148°01'E, 10 m alt., 27.x.2002, *G. Kontvilos 584/02* (HO); Yellaw Sandbanks, Moulting Lagoon, 42°05'S 148°11'E, 2 m alt., 24.xi.2004, *G. Kontvilas 4004/04* (HO); W of Tahune Bridge in the Warra SST, 43°06'S 146°41'E, 130 m alt., 28.ii.2006, *G. Kantvilas 131/06* (HO); Bisdee Tier, 42°26'S 147°17'E, 640 m alt., 22.iv.2009, *G. Kantvilas 235/09* (HO); Butlers Garge Raad near site af ald township, 42°17'5 146°16'E, 720 m alt., 2.xi.2005, *G. Kantvilos 303/05* (HO); 2 km S of Hawden near the Pawder Jetty, 43°03'S 147°18'E. 20 m alt., 21.v.1997, *G. Kantvilas 203/97* (HO); Cascades, South Habart, 42°54'S 147°17'E, 120 m alt., 11.v.2003, *G. Kantvilas 89/03* (HO); Passage Island, 40°31'5 148°19'E, 30 m alt., 6.i.1979, *J. Whinroy 1272* (HO, MEL). **AUSTRALIAN CAPITAL TERRITORY.** Canberra Nature Park, Aranda Bushland, 4 km W of Canberra, 35°16'14"S 149°04'34"E, 580 m alt., 18.vi.2005, *J. A. Elix 28822* (CANB); Aranda, 35°16'5 149°05'E, 650 m alt., 17.vi.1998, *J.A. Elix 43021* (CANB, HO). **VICTORIA.** Kew, 37°49'S 145°03'E, 3.xi.1900, *R.A. Bostow s.n.* (HO, MEL). **SOUTH AUSTRALIA.** KANGAROO ISLAND, Mt Taylor Conservatian Park, 35°56'S 137°03'E, 25.viii.1982, *K. Stove 1755 p.p.* (AD, HO); Creek Bay Farm, headwaters of Lubra Creek, 35°49'S 138°06'E, 40 m alt., 19.ix.2011, *G. Kantvilas 382/11* (HO).

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Phylloblastia blechnicola (Ascomycota, Verrucariaceae), a new leaf-inhabiting lichen from southern Victoria, Australia

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Abstract

Phylloblastia blechnicola P.M.McCarthy & Stajsic (lichenized Ascomycota, Verrucariaceae) is described from pinnae of the fern *Blechnum wattsii* in forest in southern Victoria, Australia.

Key words: taxonomy, distribution, lichen, foliicolous

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Introduction

The foliicolous (leaf-inhabiting) lichen genus *Phylloblastia* Vain. (Ascomycota, Verrucariaceae) is most diverse in the Neotropics and Australia, less so in western Europe, tropical Africa, South-east Asia and Malesia. Seven of the 14 known species occur in the wet-tropics and subtropics of eastern Australia, as well as Lord Howe Island and in warm-temperate forest in south-eastern New South Wales (Lücking 2008; McCarthy 2010).

Phylloblastia is characterised by its thin and often inconspicuous thallus, a chlorococcoid photobiont and minute, orange to greenish brown or blackish perithecioid ascomata that are usually enclosed within a spreading involucrellum and have a broad, deep apical depression. Paraphyses are lacking, but periphyses are present, as are fissitunicate 8-spored asci and usually elongate multiseptate ascospores (Lücking 2008; McCarthy 2010). Primary species-level diagnostic characters include the colour and dimensions of perithecia and the extent of involucrellar development, together with the size, shape and septation of the ascospores.

In this paper we describe a new species, *P. blechnicola* P.M.McCarthy & Stajsic, which grows on fern pinnae in forest in southern Victoria. It is also the first report of the genus *Phylloblastia* from Victoria.

Taxonomy

Phylloblastia blechnicola P.M. McCarthy & Stajsic, ***sp. nov.***
MycoBank No.: MB803177

Thallus foliicola, epicuticularis, continuus, pallide vel medie griseoviridis, c. 10–15 µm crassus, c. 0.5–1(–2) mm latus. Algae chlorococcoideae, 4–8(–12) µm diametro, fasciculatae, plerumque sparsae. Perithecia fuscovirides, convexa, (0.16–)0.25(–0.32) mm diametro, apicibus profunde concavis,

convexis ubi madefactis. Involucrellum 20–35 µm crassum. Excipulum hyalinum vel pallide fuscum, 15–20 µm crassum. Periphyses 10–20 µm longae, 2–3 µm latae. Asci 58–74 µm longi, 14–22 µm lati. Ascosporae incoloratae, (3–)5(–6)-septatae, (18–)25(–34) µm longae, (4–)5(–6) µm latae, apicibus rotundatis vel subacutis.

***Type*: VICTORIA.** c. 6 km ESE of Warburton, along Mississippi Road c. 1.9 km from its junction with Burns Road, near Big Pats Creek, 37°44'55"S, 145°46'06"E, alt. 230 m, on upper surface of living pinnae of *Blechnum wattsii*, in creek valley in open forest with *Eucalyptus radiata* and *Acacia dealbata*, 29.viii.2010, *V. Stajsic 5777 & J. Eichler* (holotype: MEL 2355655A).

Thallus crustose, epiphyllous, epicuticular, pale to medium greyish green, usually determinate and solitary, c. 0.5–1(–2) mm wide, often forming minute patches around single perithecia, c. 10–15 µm thick, ecorticate; surface continuous, matt, ± smooth to minutely uneven. *Algae* chlorococcoid; cells 4–8(–12) µm diam., scattered and very sparse to densely clustered. *Thalline hyphae* long-celled, forming a reticulum; cells 12–25 × 2.5–5(–6) µm, with thin, hyaline to medium brown walls. *Prothallus* not apparent. *Perithecia* moderately numerous, solitary, scattered, (0.16–)0.25(–0.32) mm diam. [*n* = 30], medium greenish brown, shallow-convex when wet, the base spreading and the apex becoming broadly and deeply concave when dry; concavity 0.08–0.17 mm wide; ostiole inconspicuous or slightly darker than the surrounding tissue, 20–30 µm wide. *Involucrellum* paraplectenchymatous, 20–35 µm thick, medium greenish brown in thin section, extending to excipulum base level. *Centrum* subglobose to depressed-obovate. *Excipulum* hyaline to pale brown, 15–20 µm thick, consisting of elongate, thin-walled periclinal hyphae. *Subhymenium* 15–25 µm thick. *Paraphyses* absent. *Periphyses* simple to sparingly branched, 10–20 × 2–3 µm. *Asci* fissitunicate, 8-spored, broadly ellipsoidal, obclavate or clavate-cylindrical, 58–74 × 14–22 µm [*n* = 20], usually with a broad, truncate or convex ocular chamber; ascus wall IKI–; ascoplasma IKI+ orange-brown to red-brown (with or without pre-treatment in KOH). *Ascospores* usually ± massed in a single fascicle in the ascus, colourless, transversely (3–)5(–6)-septate, oblong to oblong-cylindrical or fusiform-ellipsodial, straight or slightly curved, with rounded or subacute ends, not or scarcely constricted at the septa, (18–)25(–34) × (4–)5(–6) µm [*n* = 50]; spore wall thin, lacking an epispore; septa thin, commonly undulate or oblique; apical cells non-mucronate; contents clear. *Pycnidia* not seen. (Fig. 1.)

***Additional specimens examined*: VICTORIA.** Otway Range, Johanna, Red Johanna Road, 38°44'47"S, 143°24'37"E, alt. 76 m, on upper surface of pinnae of *Blechnum wattsii*, *V. Stajsic 4838*, 8.xi.2008 (MEL); same locality, *V. Stajsic 6401, N.G. Karunajeewa, R. & E. Mayfield*, 26.viii.2012 (MEL).

***Distribution and habitat*:** This new foliicolous lichen is known from two localities in southern Victoria, *viz.* the type locality near Warburton (east of Melbourne), and from private property at Johanna, in the Otway Range (south-western Victoria). At the type locality it grows in a creek valley, in damp open forest dominated by *Eucalyptus radiata* Sieber ex DC., with an understorey of *Acacia dealbata* Link subsp. *dealbata*, *Blechnum nudum* (Labill.) Mett. ex Luerss., *Blechnum wattsii* Tindale, *Cyathea australis* (R.Br.) Domin, *Dicksonia antarctica* Labill., and *Pomaderris aspera* Sieber ex DC. At the Johanna site it occurs in a gully near a creek, in tall open forest dominated by *Eucalyptus cypellocarpa* L.A.S.Johnson and *Eucalyptus obliqua* L'Hér., with an understorey of *Acacia melanoxylon* R.Br., *Blechnum wattsii*, *Coprosma quadrifida* (Labill.) B.L.Rob., *Cyathea australis*, *Olearia argophylla* (Labill.) Benth. and *Tetrarrhena juncea* R.Br. A limited search for additional populations of the new species was carried out across the Otway Range in late August 2012, without success. At the Johanna site the extent of *Blechnum wattsii* is no greater than approximately 3 square metres, with *Phylloblastia blechnicola* found only on a few fronds. A survey of the Warburton area, and other potential sites in Victoria is required to determine the conservation status of the new species; it is currently not known from any conservation reserves.

***Etymology*:** The epithet is derived from the fern *Blechnum wattsii*, the only known host of the new species.

***Discussion*:** *Phylloblastia blechnicola* is characterised by very small and inconspicuous, greenish brown perithecia that are deeply concave apically when dry, combined with comparatively small and elongate, (3–)5(–6)-septate ascospores. The most similar species, *P. alvari* (Herrera-Campos & Lücking) Lücking, is known with certainty only from tropical rainforest in Mexico (Lücking 2008). That

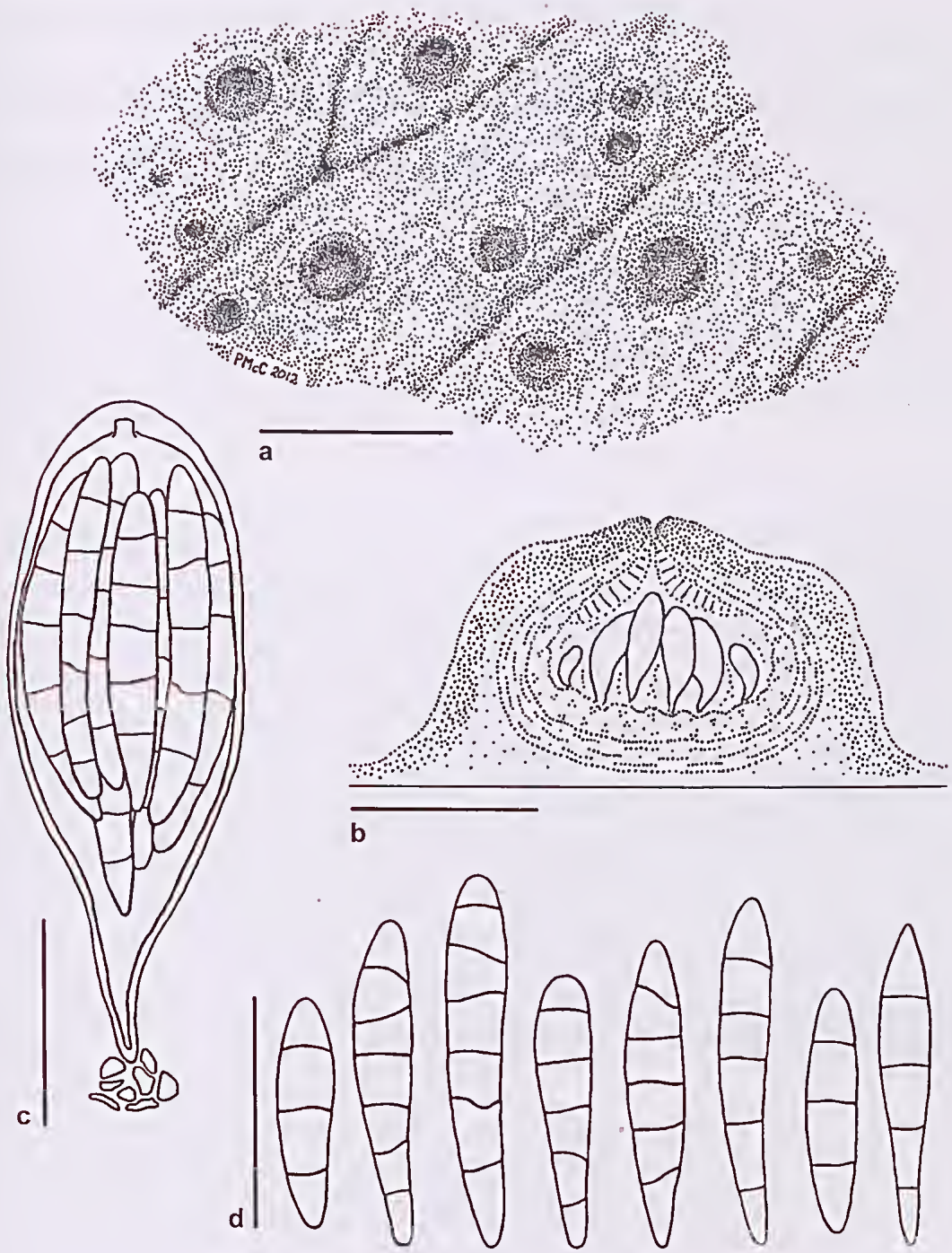

Figure 1. *Phylloblastia blechnicola* (holotype): **a.** habit of thalli and perithecia; **b.** vertical section of perithecium (semi-schematic); **c.** mature ascus; **d.** ascospores. Scale bars: a = 0.5 mm; b = 0.1 mm; c, d = 20 µm.

lichen has a similarly dispersed thallus, diminutive, apically concave perithecia and 3–7-septate ascospores. However, the ascospores are narrower and more elongate than in *P. blechnicola* (30–40 × 3–4 µm) and the asci are 70–90 × 30–40 µm (Lücking 2008). Among the Australian taxa, the endemic *P. triseptata* (Kalb & Vězda) Lücking has persistently 3-septate ascospores (Vězda & Kalb 1991), while mature ascospores of the pantropical *P. septemseptata* (Vězda) Lücking and the tropical African *P. dispersa* (Vězda) Lücking are 7-septate, and the perithecia are yellow to orange and hemispherical (Vězda 1982; McCarthy & Lücking 2001; Lücking 2008).

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Two new species of *Nitella* (Characeae, Charophyceae) from arid-zone claypan wetlands in Australia

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Introduction

Charophytes are macroscopic green algae that grow in wetlands, streams and rivers world-wide. The charophyte flora of Europe is relatively well known (Corillion 1957; Wood 1965; Moore 1986; Krauss 1997; Bruinsma 2010; Romanov and Kipriyanova 2010), but, until recently, few regions of Australia have been well-surveyed for charophytes (*c.f.* van Raam 1995; Garcia 1999; Casanova 2007a, 2007b; Garcia & Chivas 2006). In general, brief surveys for charophytes will reveal only the most common, widespread or perennial species (e.g. *Nitella hyalina* Ag. and *Chara globularis* Thuill.). Collections of short-range endemic species (e.g. *Nitella tumida* Nordst.), annual species (e.g. *Nitella sonderi* A.Braun) cryptic species (e.g. *Nitella verticillata* (Fil. et G.O.Allen ex Fil.) R.D.Wood) or rare species (*Lychnothamnus barbatus* (Meyen.) Leonh.) depends on luck (Casanova *et al.* 2003) or repeated, thorough surveys and culture of seed bank material (e.g. Casanova and Karol 2008). Recently such thorough surveys of the Paroo region wetlands of New South Wales (Porter *et al.* 2007) and wetlands of the Pilbara region of Western Australia (Pilbara Biological Survey, McKenzie *et al.* 2009) have been undertaken.

The genus *Nitella* is characterised by furcate (forked) branchlets, terminal antheridia and a 10-celled coronula on the oogonium (Wood 1965). Charophytes are usually recorded from clear-water habitats (Coops 2002), and are notable for reducing turbidity and maintaining 'clear-water' in water bodies (van Nes *et al.* 2002). Most researchers would not think to look in or try to find charophytes in naturally turbid water bodies. Despite that, charophytes have been shown to cope with very low light levels in the germination phase (de Winton *et al.* 2004), and to grow at depth in clear lakes, at the limits of photosynthetically active radiation (PAR) (Schwarz *et al.* 1996). A large number of water bodies in Australia, including rivers, man-made dams and claypans, are

Abstract

Two new species of *Nitella* Ag. are described. The species are dioecious and grow in temporary arid-zone wetlands called 'claypans'. Both have somewhat inflated, bicelluate fertile dactyls and neither species has mucus associated with the reproductive whorls. *Nitella parooensis* M.T.Casanova & J.L.Porter is characterised by its apparently pluricelluate sterile branchlets with acute, conical end cells, inflated bicellulate dactyls and uniquely twisted oogonia and oospores. *Nitella micklei* M.T.Casanova is characterised by a crisp, inflated appearance, large antheridia and distinctive oospores. The ornamentation on the oospores of both species is essentially reticulate, but for *N. micklei* there are 1–2 thick-walled meshes across the fossa, and in mature oospores of *N. parooensis* the 3–4 meshes have scattered, acute papillae within them.

Key words: Paroo, Pilbara, charophyte, oospore, morphology

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turbid from suspension of inorganic clays (Casanoval *et al.* 2007), rather than algal abundance. This is the first report of charophytes that occur in such turbid habitats.

Materials and methods

Collections of *Nitella* were made from three temporary freshwater wetlands (Woolshed Swamp, Cricket Pitch Claypan and Number 17 Claypan) in Nocoleche Nature Reserve in the arid north-west of New South Wales, within the Paroo-Warrego drainage division. The climate is classified as 'hot desert' under the modified Köppen climate system (Köppen 1918). Annual average rainfall at Wanaaring (29.43° S, 142.01° E; the closest meteorological centre) is 276 mm, with average maximum temperatures reaching 35–45°C in summer and 16–22°C in winter (Cunningham *et al.* 1981). Mean annual evaporation rates are high throughout the area (2400–2800 mm/year) so average annual surface run-off in the Paroo drainage division is low (17 mm) and this, combined with low topographic relief, encourages the formation of shallow, temporary, closed depressions (Paijmans *et.al.*1985). On average minor floods in the Paroo occur several times a year, with moderate floods every 2–3 years and major floods about every 5 years (Kingsford & Porter 1999). Riverine connectivity (ability to exchange surface water with rivers) varies considerably among these wetlands and they can fill from river flooding or local rain or both.Woolshed Swamp fills mainly from Paroo River flooding, while the Cricket Pitch and Number 17 claypans fill only from local rainfall.

All collections of *Nitella micklei* were from claypan wetlands in the Paroo region of Western Australia. The region experiences an average of 290 mm of rain annually, most of it falling in the summer via cyclonic activity and thunderstorms. There is high interannual variability in rainfall due to the variability in the paths of cyclones in the region. Claypans occur on the fringes of the Fortescue Marsh and in internally draining areas of the Hammersley Range. Claypans are shallow (<60 cm deep), turbid, temporary wetlands on a red, non-cracking clay substrate (McKenzie *et al.* 2009).

Seed banks and extant plant communities were sampled during a large-scale survey of aquatic plant communities in the Paroo-Warrego and Bulloo River basins from 1988–2004 (Porter 2005), and in the Pilbara Biological Survey between 2002–2004 (McKenzie *et al.* 2009). Seed banks were sampled following the methods of Brock *et al.* (1994) or as a bulk sediment collection. Dried sediment samples were placed in shallow plastic trays, then submerged in tap water or rain water (to 30 cm depth) to stimulate germination.

Plants were either pressed or preserved in 70% alcohol for later examination with the aid of Zeiss microscopes. Oospores were removed from the plants and prepared for scanning electron microscope examination by soaking in a strong detergent solution (Crawford *et al.* 2001) for 20 minutes and removal of the enveloping cells with fine needles followed by three minutes of sonication. Oospores were mounted on stubs using carbon sticky tabs, sputter-coated in gold and examined using an SEM following the methods of Casanova and Karol (2008). Chromosome counts were made on fresh specimens that germinated from the seed bank, or on spirit preserved specimens following the methods of Casanova (1997).

Results

1. *Nitella parooensis* M.T.Casanova & J.L.Porter, *sp. nov.*

Plantae dioeciae, vix heteroclemae, axes graciles, ramuli inaequaliter 0–3-furcati, monopodiales vel quasi monopodiales, 5–7 in quoque verticillo. Ramuli steriles plurcellulares, ramuli fertiles bicellulares. Cellulae terminales conicae et acutae. Ramuli fertiles in verticullis contractis. Oosporae 290–350 µm longae, 250–290 µm latae, tortae. Ornatio reticulata, alveolae 3 vel 4 trans fossam.

***Type*: NEW SOUTH WALES.** Cricket Pitch Claypan, Paroo River region, *J.L. Porter 260* male and female, spirit preserved (r011), (holotype: MEL)

Plants dioecious, scarcely heteroclemous, to 10 cm high, internodes to 3 cm long, c. 0.4 mm wide, sterile branchlets to 3 cm long, unevenly 0–3 × furcate, monopodial or nearly so, in whorls of 5–7 at the axis nodes, with an occasional 0 × furcate accessory branchlet at the base of the whorl. Primary branchlet segments to 40 mm long, ranging from 50 to 100% of total branchlet length. Secondary branchlet segments 2 to 3 mm long. Branchlets have the potential to be 3

or more × furcate, but sometimes the development of segments is suppressed and the terminal segments appear to be pluricelluate (up to 5 cells long including the end cell). Dactyls are essentially bicellulate, to 1.5 mm long. Accessory branchlets where present are 0 × furcate (i.e. dactyls). End cells short, conical and acute, the end of the penultimate cell distinctly narrowed so that the base of the end cell is confluent with it. Fertile parts without mucus, whorls on the female plant somewhat contracted, on the male plant in distinct heads. Fertile branchlets 6 in a whorl, 2 × furcate, oogonia from 0.4 to 0.6 mm long, at first and second branchlet furcations, antheridia terminal, to 400 µm in diameter. Oospores 290–350 µm long × 250–290 µm wide, with 4–5 striae of low flanges, dark to chestnut brown. The shape differs from all other species seen so far, rather than being a flattened sphere, oospores of this species appear twisted. Oospore wall ornamentation is coarsely reticulate, with walls of the reticulum c. 8 µm wide, 3–4 meshes across the fossa. In mature oospores minute, sparse papillae occur on the walls and cavities of the reticulum. Antheridia to 0.4 mm in diameter. Chromosome number not known. (Fig. 1)

Additianal specimens examined: **NEW SOUTH WALES.** Claypan 17, Nocoleche Nature Reserve, *J.L. Porter 264*, spirit preserved (p650), MEL. Woolshed Swamp, Nocoleche Nature Reserve, *J.L. Porter s.n.*, spirit preserved , MEL.

Distribution and habitat: Claypan wetlands in the Paroo region of north-western New South Wales and south-western Queensland. Small mid- to bright-green plants lacking mucus, with spindly whorls of branchlets terminated with open groups of dactyls; antheridia more prominent than oogonia. Found on heavy clay substrates, often in water so turbid they cannot be located visually (Secchi transparency < 5 cm). Apparently capable of rapid growth and may be short lived.

Associated species: Wetlands fringed by *Eucalyptus ochrophloia* F.Muell., *E. largiflorens* F.Muell., *Eremophila sturtii* R.Br., *Dodonaea angustifolia* L.f. and *Senna* spp., *Babbagia* sp. *Chenopodium* sp. and *Scleroleana* sp with an understorey of *Duma florulenta* (Meisn.) T.M.Schust, *Acacia stenophylla* A.Cunn. ex Benth. and/or *Maireana brevifolia* (R.Br.) Paul G.Wilson. Herbaceous species can include *Eleocharis plana* S.T.Blake, *Marsilea angustifolia* R.Br., *M. drummondii* A.Braun, *Alternanthera denticulata* R.Br., *Cyperus gilesii* Benth., *Aponogeton queenslandicus* H.Bruggen and *Eragrostis australasicus* (Steud.) C.E.Hubb; submerged species include the charophytes *Chara braunii* C.C.Gmelin, *Nitella sonderi* A.Braun and *Nitella cristata* A.Braun.

Etymology: *parooensis* means 'of the Paroo'. This species has not been collected in any other place.

Conservation status: This species has been listed on the New South Wales endangered species list as *Nitella* 'parooensis'.

2. *Nitella micklei* M.T.Casanova, *sp. nov.*

Plantae dioeciae, homeoclemae, ad 10 cm altum, axes crassi, ramuli 1-vel 2-furcati, , 5–7 in quoque verticillo, dactyli inflati, bicellularis. Oosporae 200 µm × 170 µm, ornatio leniter reticulata, alveolae laeves 1 vel 2 trans fossam. Antheridia ad 500 µm diametrum.

Type: **WESTERN AUSTRALIA.** Pilbara Survey Wetland 040, Mulga Downs Outcamp Claypan, 3 km West of Cowra Line Camp Homestead, Mulga Downs Station, 67.5 km ESE of Wittenoom (S 22.3618, E 118.9774) 17.viii.2006, *M.T. Casanova PBS17:R114* (holotype: MEL).

Plants dioecious, homeoclemous, to 90 mm tall, internodes to 35 mm long. Axes stout, to 650 µm in diameter. Sterile branchlets 6 in a whorl, to 18 mm in total, 1(–2) × furcate, primary segments to 6 mm long, 2–3 secondary segments, to 2 mm long, rarely 2–3 tertiary segments, to 2 mm long. Dactyl cells swollen or inflated 1–2 mm long, 0.5–1 mm wide, sometimes narrowing distally to be confluent with the mucronate end cell, 75 µm long × 30–40 µm wide at the base. Fertile branchlets 5–6 in a whorl, to 2 mm long, 1–2 × furcate. Primary segments to 1.5 mm long, 2–3 secondary segments to 1.2 mm long, rarely 2–3 tertiary segments to 0.5 mm long. Fertile dactyls as for sterile, individual segments can be less inflated on male plants. Gametangia on separate plants in contracted whorls. Oogonia to 230 µm long, 190 µm wide, coronula to 18 µm high, 6–7 convolutions. Oospores 200 µm long, 170 µm wide, 6–7 striae of thick ridges, uniting in a small apical crest. Oospore membrane shallowly reticulate with (0–)1–2 smooth meshes across the fossa. Antheridia to 450–470 µm in diameter. Chromosomes n=9. (Fig. 2)

Additional specimens examined: **WESTERN AUSTRALIA.** PSW005 Koodjeepindawarranna Pool 19.viii.2006, *M.T. Casanova PBS40: t254* (MEL). PSW005 Koodjeepindawarranna

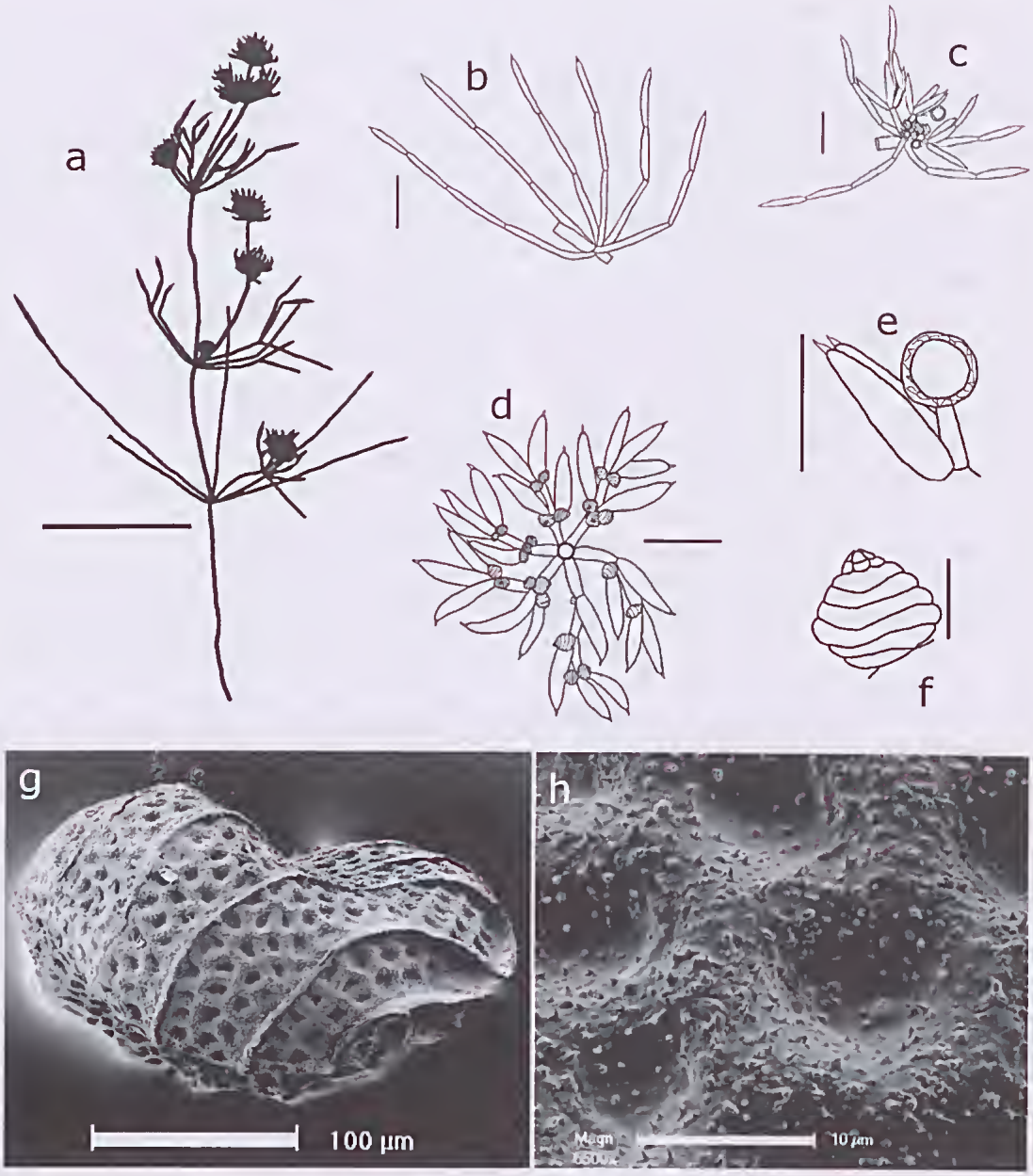

Figure 1. *Nitella parooensis* M.T.Casanova and J.L.Porter. **a.** Whole plant morphology, scale bar = 20 mm; **b.** sterile branchlet whorl showing 4–5 celled branchlets (3–4 cells plus reduced conical end cell), scale bar = 10 mm; **c.** fertile male branchlet node with 0–1 × furcate branchlets, a fertile 'head' and a stalked antheridium, scale bar = 10 mm; **d.** fertile female branchlet node with six 2–3 × furcate branchlets in a whorl, oospores occurring singly, geminate or in clusters at the branchlet nodes, dactyls swollen, scale bar = 1 mm; **e.** fertile male dactyls and stalked antheridium, scale bar = 1 mm; **f.** oogonium with both rows of coronula cells approximately the same size, exhibiting the same sinistral torsion of the oospore, scale bar = 0.2 mm; **g.** whole oospore showing twisted morphology, *c.* six striae with low flanges and reticulate ornamentation, scale bar = 100 µm; **h.** detail of oospore wall showing thick-walled meshes of the reticulum and ornamentation of scattered acute papillae (*c.* 1 µm high), scale bar = 10 µm.

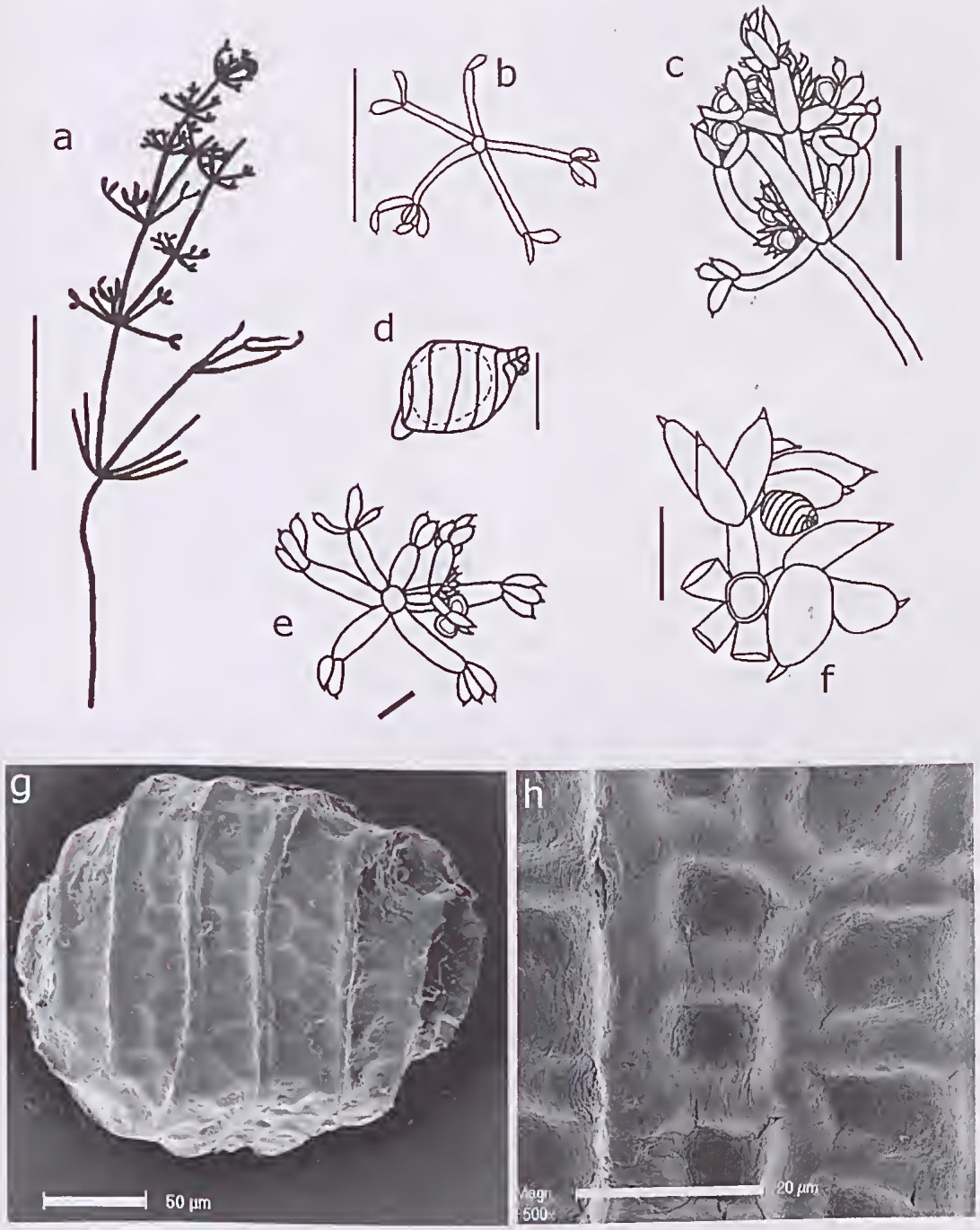

Figure 2. *Nitella micklei* M.T. Casanova. **a.** Whole plant morphology showing whorls of 1 × furcate branchlets, scale bar = 1 cm; **b.** sterile branchlet whorl with five 1–2 × furcate branchlets with inflated dactyls, scale bar = 5 mm; **c.** fertile male shoot with sessile antheridia at base of whorl and first furcations, scale bar = 1 mm; **d.** oogonium, scale bar = 100 µm; **e.** branchlet whorl with six 1 × furcate branchlets and a fertile male side shoot, scale bar = 1 mm; **f.** fertile female branchlets with oogonium at the first furcation and inflated, bicellulate dactyls, scale bar = 100 µm; **g.** whole oospore a flattened sphere 200 µm long and 170 µm wide with *c.* six striae and reticulate ornamentation, scale bar = 50 µm; **h.** detail of oospore wall showing striae of thick ridges and reticulate ornamentation with two thick-walled, shallow meshes across the fossa, scale bar = 20 µm.

Pool 19.viii.2006, *M.T. Cosanova PBS44: t257* (MEL). PSW004 Gnalka Gnoona 19.viii.2006, *M.T. Casanova PBS33: t256* (MEL). PSW010 Fortescue River at Millstream (Palm Pool) 21.viii.2006, *M.T. Cosonova PBS57:t258.* PSW041 Ethel Creek Claypan 1.viii.2004, *D.A. Mickle & M.N. Lyons 3073: t259.*

Distribution and habitat: Shallow turbid claypans in the Pilbara region of Western Australia. Small, turgid, robust plants with short branchlets held perpendicular to the stem. Male plants with large, bright orange antheridia in contracted terminal and axial shoots. The plant is often covered with a layer of fine red clay *in situ*.

Associated species: *Nitella micklei* occurs with *Riella* sp. (bryophyte).

Etymology: Named for David Mickle who, along with Mike Lyons, first collected the species.

Conservation status: Known only from the Pilbara region claypans, locally abundant in shallow water following rain.

Discussion

These two species differ from all other described species of *Nitella* in their oospore and vegetative morphology. The presence of inflated or swollen dactyls is not unique, *N. tumida* in Australia, and several species elsewhere have similar, inflated terminal branchlet segments. However, *N. tumida* has long internodes and branchlets described as 'umbellate' (Nordstedt 1891), and oospores described as 'smooth or with irregular projections' (Wood 1972). Additionally, *N. tumida* occurs in saline habitats (Nordstedt 1891), and is doubtfully recorded from freshwater (García & Chivas 2006). Within subgenus *Tieffallenia* there are a variety of oospore morphologies, but few species in that subgenus exhibit reticulate ornamentation (Leitch *et al.* 1990, Casanova 2009), *cf.* subgenus *Hyella* section *Hyella*, in which almost all species have reticulate oospores (Casanova 2009). Differentiation in oospore morphology has been found to coincide with vegetative morphological differences (John & Moore 1987; Casanova & Karol 2008; Casanova 2009), and with different nucleotide sequences (Sakayama *et al.* 2002; Sakayama *et al.* 2004; Sakayama *et al.* 2005; Sakayama *et al.* 2006). Oospore differences have been used for more than a century to differentiate among charophyte species (Nordstedt 1889; Allen 1896; Williams 1959; Casanova & Karol 2008; Casanova 2009) and only Wood (1965) amalgamated species with different oospore morphologies. On the basis of their distinctive oospores alone these taxa would be distinguished as different species. However, they are also vegetatively distinct from other species of *Nitella*.

The overall shape of the oospore of *N. parooensis* is unique. All other known species of *Nitella* have oospores that are a flattened oval or flattened sphere, so that the definition of the genus (Wood 1965) includes that description. Oospores of *N. parooensis* are essentially a flattened sphere, but the resulting 'disc'-shape is twisted sinistrally. Thus the circumscription of the genus *Nitella* should be amended so that the description of the oospores is 'oospores a flattened sphere or oval or *rarely a flattened sphere sinistrally twisted*'.

Arid zones are not, at first glance, likely habitats for charophytes and other water plants. However, despite the intermittent, unpredictable occurrence of free water for more than a few days at a time, a number of cryptogamic plant and algal species not only occur but also thrive in arid-zone wetlands (Hussain & Khoja 1999, Proctor 1972, Porter 2007, Powling 2009).

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Maireana obrienii (Chenopodiaceae), a new species from eastern Australia

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Abstract

Maireana obrienii N.G.Walsh, *a* new species with affinities to *M. decalvans* (Gand.) Paul G.Wilson, recorded from the Brigalow Belt, South-west Slopes and Riverina regions of Queensland, New South Wales and Victoria, is described and illustrated. Its distribution and ecology are discussed.

Key words: taxonomy, distribution, Chenopodiaceae.

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Introduction

Botanical surveys in northern Victoria and southern New South Wales have detected an entity with affinities to *Maireana decalvans* (Gand.) Paul G.Wilson but with some significantly divergent traits. Comparison of a wide range of herbarium material of *M. decalvans* with the 'aberrant entity' and field visits to where the two entities are sympatric suggest recognition of a new species is warranted. The most recent treatments of *Maireana* (e.g. Wilson 1975, 1984) do not describe the features of the new species, suggesting it has been hitherto overlooked in herbarium collections and the field.

Taxonomy

Maireana obrienii N.G.Walsh, ***sp. nov.***

a M decalvanti *perianthio fructu latiore ramulis glabris differt.*

***Type*: VICTORIA.** Pine Grove near Mitiamo, immediately north of Pine Grove Recreation Reserve (Rifle Range), 28.iv.2012, *N.G. Walsh 7532, E. O'Brien & J.P. Walsh* (holotype MEL 2357436; isotypes AD, CANB, NSW).

Perennial *shrub* with stout fusiform taproot to at least 3 cm diam and 50 cm long (probably more). *Branches* more or less erect, to 80 cm high. *Stems* striate, reddish, glabrous except for *conspicuous white tufts* of hairs in axils. *Leaves of mature plants* narrowly ovoid to clavate, 3–6(–10) mm long, 1.5–2 mm wide (when dry), l/w ratio generally <5 (to *c.* 3 mm wide and l/w ratio 2–3 when fresh), glaucous. *Leaves of juvenile plants* typically longer, to 22 mm. *Fruiting perianth* glabrous, or the tepals sparsely ciliate at apices, wing 10–12 mm diam, quite flat, margin (apart from radicular slit) entire to shallowly and irregularly sinuate, with no suggestion of discrete lobing, nearly white to pale green when young and with conspicuous rosy pink marginal rim, finally grey-brown with numerous fine anastomosing blackish veins before falling from the plant. Thickened

central part of fruit (fruiting perianth tube) 3.5–4.5 mm diam. *Utricle* (2.5–)3–3.5 mm diam. Flowers and fruits Dec.–May, mostly in autumn. (Fig. 1)

Specimens examined: **QUEENSLAND.** BRIGALOW BELT SOUTH 51 km W of Miles, *K.R. McDonald 260* (BRI); 14 miles [24 km] W of Tara, *T.J. McDonald 76* (BRI, MEL); Between Yelarbon and Goondiwindi, *L.S. Smith 14211* (BRI); **NEW SOUTH WALES.** RIVERINA, Griffith, *G.R. Sainty 143* (NSW); 1.3 km WSW of Jerilderie, 22.v.2012, *E. O'Brien s.n.* (CANB, MEL); Cobb Hwy, 15 km S of Mathoura, 13.v.2012, *E. O'Brien s.n.* (CANB, MEL, NSW); SOUTH WESTERN SLOPES, Forbes, *B. Whitehead 2* (PERTH). **VICTORIA**. RIVERINA, Whitfield Rd, Terrick East, 6.vi.2012, *E. O'Brien s.n.* (BRI, MEL, NSW); Echuca Railway Reserve, 4.8 km SSE from town centre, 13.v.2012, *E. O'Brien s.n.*(MEL); O'Tooles-Leahys Rd, Terrick Terrick, 6.vi.2012, *E. O'Brien s.n.* (AD, MEL, NSW); Jasper Rd, *c.* 500 m W of Bendigo-Tennyson Rd, *W.A. Gebert 236, E.A. James & R. Jordan* (CANB, MEL, PAL, S); Bayliss Rd, 100 m S of Olds Rd, SE of Prairie, *W.A. Gebert 230, E.A. James & R. Jordan* (MEL, PAL, S); Bayliss Rd, Prairie, 13.v.2012, *E. O'Brien s.n.* (MEL, PERTH); VICTORIAN MIDLANDS, Inglewood Conservation Reserve, *W.A .Gebert 244, E.A. James & R. Jordan* (MEL, PAL, S); Loddon West Rd, 5.8 km SSW of Serpentine, 18.v.2012, *E. O'Brien s.n.* (AD, BRI, MEL).

Distribution and habitat: *Maireana obrienii*, as far as is known, is largely confined to the Riverina region (*sensu* IBRA 2012) occurring in an arc from near Jerilderie in south-central New South Wales south and west to near Serpentine in Victoria. The mean annual rainfall through this area is 375–425 mm. An outlying occurrence in the South Western Slopes region (*sensu* IBRA 2012) of New South Wales is known. Three collections from the southern Brigalow Belt (*sensu* IBRA 2012) in Queensland are tentatively referred to *M. obrienii* (see below).

In the Riverina, the species is of restricted occurrence in the northern part of its range, where it occurs mainly in the Moama–Mathoura area, with some isolated occurrences in grasslands near Jerilderie and Conargo. It is common in a restricted area in Victoria, especially on the grassland plains west and east of Echuca, including

Figure 1. *Maireana obrienii* at type locality, photographed by the author, 28.iv.2012

Table 1. Comparison of key morphological features of *Maireana obrienii* and *M. decalvans*

	M. obrienii	*M. decalvans*
Habit	Erect, to *c.* 80 cm high	Usually sprawling, to *c.* 50 cm high
Stem (other than axillary hair tufts)	Glabrous	Pubescent with fine pale brown hairs, becoming glabrous with age
Leaves	Clavate to ellipsoid, 1.5–2 mm wide, l/w ratio <5 when dry (typically to *c.* 3 mm wide and l/w ratio 2–3 when fresh)	Cylindric to narrow-ellipsoid, *c.* 1 mm wide, l/w ratio > 5 when dry (typically to *c.* 1.5 mm wide and l/w ratio >4 when fresh)
Fruiting perianth wing	10–13 mm diam, unlobed, flat to very weakly undulate, white to pale green with a distinct rosy pink margin before darkening	6–8(–9) mm diam, often shallowly *c.* 5-lobed and pleated, straw coloured, with or without indistinct orange-reddish rim before darkening
Fruiting perianth tube	3.5–4.5 mm diam	2–3 mm diam
Mature utricle	(2.5–)3–3.5 mm diam	1.5–2 mm diam

Terrick Terrick National Park and other reserved areas. Occurrences north-east of this range near Lockhart (New South Wales) and near Inglewood (Victoria) in the south-west are suspected to be unnatural as they are in disturbed roadside vegetation in atypical habitat (woodlands of *Eucalyptus microcarpa* (Maiden) Maiden and *Callitris columellaris* F.Muell. and eucalypt mallee respectively). The isolated specimens from Forbes and southern Queensland suggest a more extensive range, but it is not known if the apparent gap in distribution is real or an artifact of collection effort.

As far as is known, the typical habitat for *M. obrienii* is grassland or open woodland, occurring on hard-setting red-brown clay loam or on self-mulching clays where these occur in close proximity to the more typical clay loam. Species commonly associated with *M. obrienii* include *Atriplex semibaccata* R.Br., *Austrostipa nodosa* (S.T.Blake) S.W.L.Jacobs & Everett, *Enteropogon acicularis* (Lindl.) Lazarides, *Goodenia* spp., *Leiocarpa* spp., *Maireana decalvans* (Gand.) Paul G.Wilson, *M. pentagona* (R.H.Anderson) Paul G.Wilson, *Rytidosperma caespitosum* (Gaudich.) Connor & Edgar, *R. setaceum* (R.Br.) Connor & Edgar, *Sida corrugata* Lindl. and *Sporobolus caroli* Mez.

Collectors' notes accompanying the three specimens from Queensland suggest a similar fertile clay substrate to sites of the Riverina, at least sometimes with gilgais. Mean annual rainfall for the region is around 490 mm. In this region, *M. obrienii* occurs in *Acacia harpophylla* F.Muell. ex Benth. and *Eucalyptus populnea* F.Muell. woodlands.

Biology: Plants of *Maireana obrienii* usually die back to the base during winter and early spring, with new stems forming as warmer weather arrives in late spring and early summer. Rapid growth, flowering and fruiting typically occurs in autumn. Abundant fruiting and recruitment occurs under favourable conditions, especially following extended drought, which appears to increase both seed production and recruitment success. Germination typically occurs on the soil surface in autumn, usually within a few days of sufficient rainfall. Buried seed does not seem to germinate. The species does not form a lasting seedbank with seed retaining viability for only a few months under field conditions, and less than 12 months in storage at ambient conditions (E. O'Brien pers. obs.).

Relative abundance of *M. obrienii* can vary greatly depending on seasonal conditions. Density can increase rapidly during a series of dry seasons, then decrease dramatically following high rainfall years.

The species has been cultivated as a pasture species on farmland at Pine Grove for 10 years, where it has proven to be a useful fodder species, especially during drought or a late autumn break (E. O'Brien pers. comm.).

Notes: The new species differs from *Maireana decalvans*, with which it is often associated in the field, in being (at least in the Riverina) generally a taller, more erect plant, with stems that are quite glabrous apart from the axillary hair tufts. The leaves are generally broader, often clavate, and the fruiting perianth tube and wings are larger as are the mature utricles. The wings of the fruit are typically more colorful than those of *M. decalvans* and show no sign of lobing or pleating – states that are often found in *M. decalvans*. Table 1 summarises the differences between the two species.

Specimens of *M. decalvans* may be as tall as, or taller than *M. obrienii* in areas outside the Riverina. A specimen from near Dooen in Victoria, is claimed to have been from a plant in excess of 1.8 m high (*W. Clarkson s.n.*, MEL 722215). Nonetheless, through the Riverina, the form of *M. decalvans* is typically a squatter plant than *M. obrienii* and readily distinguished in the field. *Maireana decalvans* is widespread from central Queensland to southern Victoria and South Australia and locally common. It appears to be tolerant of a wider range of temperature, rainfall and soil types.

The three Queensland specimens cited above differ slightly from the southern collections. While they have the characteristic glabrous stem internodes, the fruits (wings, perianth tube and utricle) are the smallest seen for the species and approach (but do not quite reach) the dimensions of these structures in *M. decalvans*. Typical *M. decalvans* specimens are common through the area encompassed by the Queensland *M. obrienii* specimens. They are readily distinguished in the herbarium by the pubescent young stem internodes. Nonetheless, further collections of the species in the Brigalow Belt would be useful to clarify the boundaries between the two species in this region.

Only one collection (*McDonald 76*) of *M. obrienii* was found amongst the 107 sheets of *M. decalvans* (the most likely species to be confused with it) at MEL prior to the 2012 collection from which the type was designated. A few specimens have been determined from collections at BRI, NSW and PERTH. It is possible that further specimens exist in other herbaria. The species has undoubtedly been depleted through much of its range through land clearance, grazing and cultivation (E. O'Brien pers. comm.).

Maireana obrienii is vulnerable to grazing during the main fruiting period, although grazing or pruning prior to the main growth period may promote new shoot development. It is also susceptible to damage by chemical spray drift, especially where roadside remnants occur adjacent to cropping land (E. O'Brien pers. comm.).

The epithet honours Mr Eris O'Brien, farmer and naturalist, whose extensive knowledge of the vegetation of the Riverina has resulted in many new discoveries and contributed considerably to the understanding and protection of significant remnants in this region. Eris first brought this new species to my attention and kindly contributed the distributional and ecological information provided above.

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A new mallee species *Eucalyptus phoenix* (Myrtaceae) from Brumby Point, East Gippsland, Victoria

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Introduction

The authors first observed this new entity at Brumby Point on the Nunniong Plateau in May 2002, prior to the severe summer fires of early 2003. One small stand of c. 30 dwarf mallees was noted at the eastern end of the Brumby Point Track. Two additional stands were noted on rocky outcrops north of the track: c. 20 dwarf mallees c. 100 m west of the first stand and c. 40 dwarf mallees c. 250 m west of the first stand. The only collection taken at this time was a small amount of vegetative material. While fruiting material was noted, none was collected at the time. It was not until late spring of 2003 that we returned to the fire-devastated landscape of Brumby Point where, to our amazement, we recovered a small number of unopened seed capsules from one of the severely burnt mallees at the eastern end of Brumby Point Track. It was from these that seedlings were grown at Facey's Nursery, Cranbourne, Victoria in an attempt to clarify the identity of this enigmatic dwarf mallee. The degree of uniformity in seedling characters proved to be consistent with a stable entity rather than a hybrid taxon. Furthermore, the hispid seedling leaves and stems, and the occasional slightly oblique leaf bases, tentatively locate the new taxon in the stringybark series *Pachyphloiae* Blakely of *Eucalyptus* L'Her. Growth trials bringing these seedlings to flowering and fruiting furnished further evidence of the stability of the new taxon throughout all life stages. Subsequent collection of flowering type material was taken from the field in November 2010, by which time post-fire regeneration had advanced sufficiently to confirm the distinctive characters demonstrated by seedling and growth trials at a field population level.

Taking into consideration the suite of characters that separate this entity from other stringybarks we consider it worthy of recognition at species rank.

Abstract

A new species of *Eucalyptus* L'Her. with remote affinities to *Eucalyptus mackintii* Kottek is described. *Eucalyptus phoenix* Molyneux & Forrester *sp. nov.* is a rare dwarf mallee currently known from three small stands at Brumby Point on the Nunniong Plateau in the Alpine National Park, East Gippsland, Victoria. Its distribution, ecology, affinities and conservation status are discussed.

Key words: mallee, stringybark, series *Pachyphloiae*, morphology, taxonomy

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Taxonomy

Eucalyptus phoenix Molyneux & Forrester, ***sp. nov.***

A new species with affinities to *Eucalyptus mackintii* as suggested by hispid seedling leaves and stems, conical bud operculae and hemispherical fruit but differing by its mallee habit, bark smooth except at base and peduncles occasionally paired.

***Type*: VICTORIA.** Eastern end of the Brumby Point Track, 37°03'12" S, 148°04'42" E, 15.xi.2010, *W. Molyneux & S. Forrester s.n.* (Holotype MEL 2360702; Isotypes: AD, CANB, K, NSW, NY, S).

Dwarf *mallees*, 2–5m tall. *Lignotuber* present. *Bark* smooth almost to the ground, white to light grey; old bark at base sometimes forming a short stocking of flaky bark decorticating as thin strips and plates. *Seedling leaves*, ovate, cordate, opposite for 3 or 4 pairs, petiolate, discolorous, dark green above, pale green below, hispid for 5 or 6 pairs; margins hispid. *Seedling stems* round in cross section, hispid. *Juvenile leaves* ovate, rarely basally oblique, acuminate or apiculate, alternate, petiolate, non-hispid, slightly discolorous, dull, light green or blue green, 5–8 cm long, 1.5–4 cm wide; *petioles* 4–11 mm long. *Intermediate leaves* ovate or sub-orbicular, petiolate, slightly discolorous, dull blue-green, broader than juvenile leaves; lateral and intramarginal veins prominent on both surfaces. *Adult leaves*, lanceolate to broadly lanceolate or ovate lanceolate, symmetric or sometimes slightly basally oblique, apex apiculate or acuminate, uncinate, sparsely reticulate, concolorous, lustrous, green, (4–)8–10(–13) cm long, (1.8–)2–3(–3.8) cm wide; lateral veins prominent, inclined at 30–40 degrees from the mid-vein, intramarginal vein prominent, remote, 3–5 mm from the margin, oil glands abundant, regular, island; petioles 1–1.7 cm long. *Inflorescences* axillary, solitary or sometimes twinned, 5–11-flowered; peduncles slender, terete or slightly angular, (2–)8–14 mm long. *Floral buds* clavate, pedicellate, unscarred, 3–4-locular, 6–8 mm long, 3–4 mm wide; pedicels 3–4 mm long; operculum conical, flush with the hypanthium at the abscission zone, tinged red prior to anthesis, 3–5 mm long, 3–4 mm wide; stamens irregularly flexed, all fertile; filaments white; anthers sub-basifixed, versatile, reniform, dehiscing through oblique confluent slits. *Ovules* in two longitudinal rows. *Fruits* often clustered on leafless branches, hemispherical, thick-walled, subsessile or shortly pedicellate, 7–8 mm long, 6–8 mm wide; pedicels 1–2 mm long; disc narrow and slightly folded, level with rim or occasionally shallowly ascending in old fruit; valves 3 or 4, triangular, level with disc. *Fertile seeds* dark brown, irregularly sub-pyramidal, dorsal surface shiny, minutely and unevenly verruculose; hilum ventral. (Fig. 1A–F)

***Flowering period*:** Late spring to early summer.

***Additional specimens examined:* VICTORIA.** Cultivated at Dixons Ck (from seed collected late spring 2003 from upper northerly slopes north of Brumby Point Track, *c.* 100 m west of Brumby Point, 37°03'12" S, 148°04'37" E), 24.xii.2006, *W. Molyneux & S. Forrester s.n.* (MEL 2331166, 2331167); Cultivated at Dixons Ck (from seed collected late spring 2003 from upper northerly slopes north of Brumby Point Track, *c.* 250 m west of Brumby Point, *c.* 6.8 km. from Diggers Hole Spur Track, 37°03'12" S, 148°04'32" E), 20.vi.2008, *W. Molyneux & S. Forrester s.n.* (MEL 2331168, 2331169).

***Distribution and habitat*:** *Eucalyptus phoenix* is currently known only from a single small population at Brumby Point on the Nunniong Plateau in the Alpine National Park in East Gippsland, Victoria. The population comprises three small stands near the eastern end of Brumby Point Track and upper northerly slopes immediately to the west. The habitat is a spur at an elevation of *c.* 1360 m asl supporting sub-alpine woodland dominated by a unique suite of mallee and dwarf eucalypts. Geology is strongly tilted and banded metamorphosed siltstone of Palaeozoic age.

***Associated species*:** *Eucalyptus* aff. *dives* Schauer, *E. elaeophloia* Chappill, Crisp & Prober, *E. forresterae* Molyneux & Rule, *E. kybeanensis* Maiden & Cambage, *E.* aff. *kybeanensis*, *E. mannifera* Mudie subsp. *mannifera* and *E. pauciflora* Sieber ex Spreng. subsp. *pauciflora* have been observed growing near or adjacent to *Eucalyptus phoenix*. *Eucalyptus dalrympleana* Maiden subsp. *dalrympleana*, *E. glaucescens* Maiden & Blakely and *E. perriniana* F.Muell. ex Rodway also occur in the vicinity of Brumby Point. The site has outstanding biogeographic significance as a 'hot spot' for a suite of endemic and rare species and disjunct plant populations (Chappill *et al.* 1990) including a population of *Acacia lucasii* Blakely (known in Victoria only from here and a site shortly to the east), *Actinotus forsythii* Maiden & Betche and

Figure 1. A. Seedlings, illustrating uniformity and hispid juvenile growth; **B.** young plant illustrating hispid growth; **C.** smooth-barked stem of an 8-year-old *Eucalyptus phoenix* cultivated at the authors' property; **D.** buds and flowers; **E.** mature fruit; **F.** adult leaf venation pattern and uncinate leaf tip

Monotoca rotundifolia J.H.Willis, all of which are disjunct outliers from southern New South Wales. The site also supports the type populations of three other highly restricted Victorian endemics: *Eucalyptus forresterae* (Rule & Molyneux 2011), *E. elaeophloia* (Chappill *et al.* 1990) and *Leptospermum jingera* Lyne & Crisp (Lyne & Crisp 1996). Other rare species with populations at Brumby Point include *Grevillea pachylostyla* (McGill.) P.M.Olde & N.R.Marriott, *Monotoca oreophila* Albr. and *Viola improcera* L.G.Adams.

***Conservation status*:** The new species is restricted to a single known population comprising fewer than 100 mature individuals in three small stands with an estimated extent of occurrence of 5000 m^2 based on a linear extent of 250 m and maximum average width of 20 m and an estimated area of occupancy less than 0.5 ha. The species is arguably subject to continuing decline in the quality of its habitat as a consequence of the inferred and projected impact of climatic drying and elevated temperature thresholds on the recruitment potential of almost all Victorian montane to subalpine eucalypts (Nitschke & Hickey 2007) and, by inference, *E. phoenix*. The species is therefore assessed as critically endangered under the IUCN Red List categories and criteria (IUCN 2001) with a threat code of CR B1ab(iii)+2ab(iii). The species also qualifies unambiguously as endangered under criterion D since the estimated population size is well below the threshold of 250 mature individuals (EN D).

***Etymology*:** The epithet *phoenix* commemorates the serendipitous discovery of a small amount of seed of this rare new plant following the apparently all-consuming fire of 2003. Like the fabled bird of Greek mythology *Eucalyptus phoenix* arose from the flames of a fire.

***Recommended English name:** Brumby Mallee-gum.*

Discussion

Eucalyptus phoenix appears to have its nearest (although still somewhat remote) affinity with *E. mackintii* (Kottek *et al.* 1990) through the shared hispid seedling leaves and stems, the buds with a conical operculum and similar fruit shape. The new species differs in its mallee habit, smooth bark, occasionally paired peduncles, pedicellate buds (sessile in *E. mackintii*) and fruit with a narrow, more or less level disc (broader, more or less ascending in *E. mackintii*).

Eucalyptus phoenix also demonstrates more distant affinity with *E. macrorhyncha* as illustrated by the shared hispid seedlings and oblique adult leaf bases but differs markedly by its smooth rather than fibrous bark and smaller fruits with a level or shallowly ascending disc (in contrast to the strongly ascending disc of *E. macrorhyncha*).

Eucalyptus phoenix is tentatively placed within *Eucalyptus* series *Pachyphloiae*, noting that *E. phoenix* is not unique amongst the stringybarks in having smooth or flaky bark and mallee habit. Other species of 'stringybark' sharing these traits include *E. olsenii* L.A.S.Johnson & Blaxell, *E. deuaensis* Boland & P.M.Gilmour, *E. serraensis* Ladiges & Whiffin and *E. verrucata* Ladiges & Whiffin.

Acknowledgements

Kevin Rule for his invaluable editorial assistance, in particular his knowledge of the *Eucalyptus* series *Pachyphloiae* which led us to more fully appreciate the uniqueness of *E. phoenix*. David Cameron for his advice on the structure of this paper and painstaking and meticulous editorial assistance. The staff at The National Herbarium of Victoria (MEL) for providing access to specimens. Raelene Trimble of Facey's Nursery for conducting the initial seedling trials. A final thanks to Neville Walsh (MEL) for the numerous Latin diagnoses he has provided for us over many years prior to this requirement becoming optional.

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An examination of *Pterostylis xerophila* (Orchidaceae) and the confirmation of *P. lingua* as a new species in Victoria

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Introduction

Pterostylis xerophila M.A.Clem. (Desert Greenhood) is a small terrestrial orchid found in inland South Australia and Victoria. This species is only known from eight widely distributed wild populations containing about 150 plants (Duncan 2010). *Pterostylis xerophila* is listed as 'vulnerable' under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*, 'threatened' under the Victorian *Flora and Fauna Guarantee Act 1988* and 'endangered' in the Department of Sustainability and Environment's (DSE) *Advisory List of Rare or Threatened Vascular Plants in Victoria – 2003* (DSE 2003).

The traditional concept of the genus *Pterostylis* R.Br. (Pterostylidinae: Cranichideae) as interpreted by Brown (1810), Lindley (1840); Bentham (1873), and Janes and Duretto (2010) contains approximately 216 species. Victoria has about 60 species within seven well-recognised groups (Jeanes & Backhouse 2006). One of the most recognisable of these groups, known as the 'rufa group', is characterised by: a basal rosette of sessile, overlapping leaves that are usually withered by flowering; an erect one to multi-flowered inflorescence and flowers where the dorsal sepal and petal margins join to form a galea that encloses the column; lateral sepals synsepalus, fused over their basal half and terminating in long thread-like tips; an actively mobile labellum, attached near the base by an elastic strap, exposed in the set position in front of the lateral sepals; an unlobate, swollen basal region; labellum margins often with conspicuous long white setae and usually some short setae; and a notched apex.

The genus *Oligochaetochilus* Szlach. was first proposed for the 'rufa group' of *Pterostylis* by Szlachetko (2001). Subsequently, Jones and Clements (2002a,b) and Jones *et al.* (2004) accepted the name in a much modified and more restricted form. This later circumscription was confirmed by multigene analysis (Clements *et al.* 2011). Nevertheless,

Abstract

This paper examines all known populations of *Pterostylis xerophila* M.A.Clem. within Victoria based on accurate surveys of known habitat carried out in October 2009–2012, collecting floristic and environmental information relevant to community ecology and condition. Twelve sites were surveyed for *P. xerophilo*. Populations of *P. xerophila* were confirmed only in the Murray-Sunset National Park. Populations in Semi-arid Parilla Woodland in the northern Murray-Sunset National Park, Mallanbool Fauna and Flora Reserve (FFR) and Wemen FFR previously thought to be *P. xerophila* were determined by the authors to be *P. linguo* M.A.Clem., a new species for Victoria.

Key words: Semi-arid Parilla Woodland, habitat, threatened species, orchid, *Pterostylis*

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this interpretation has not yet been widely accepted in Victoria and, for the sake of clarity for Victorian users of plant names, the authors have decided to treat the 'rufa group' as *Pterostylis* in this paper. In *Pterostylis* the group is classified as subgenus *Oligochaetochilus* section *Oligochaetochilus* (Janes & Duretto 2010).

Currently the 'rufa group' comprises 17 described Victorian species plus several putative undescribed taxa, some of which may have been previously included within *P. xerophila*. An action in the proposed 2010 Recovery Plan for *P. xerophila* was to accurately identify all populations, particularly the disjunct ones, throughout Victoria (Duncan 2010).

Pterostylis xerophila was described by Mark Clements in 1986, based on plants in cultivation that were collected at Wynbring in the Great Victoria Desert, South Australia (Clements 1989). The species has been a taxonomic 'dumping ground' for a suite of dry-land rufa greenhood taxa (particularly in Victoria). This, combined with infrequent observations of plants, has led to confusion as to the identity, distribution and conservation status of *P. xerophila*.

According to Australia's Virtual Herbarium there are currently only four herbarium specimens determined as *P. xerophila* originating from Victoria, from three sites (Wemen FFR, Mallanbool FFR and Millewa South Bore in the Murray-Sunset National Park). All other sites mentioned for this species in the Recovery Plan (Duncan 2010) are based on field observations that have not been taxonomically confirmed. For example, anecdotal information in the *P. xerophila* Recovery Plan (Duncan 2010) refers to the existence of two populations in Wyperfeld National Park but there are no herbarium collections from this site. Additionally, a population of uncertain taxonomic placement has been recorded by DSE staff from Settlement Road in the Murray-Sunset National Park. Unconfirmed reports of *P. xerophila* from Annuello and Wandown in north-west Victoria are unlikely to be that species, although they warrant investigation and clarification. Reports of 'rufa greenhoods' at Neds Corner, Pink Lakes and Walpeup have been confirmed as *P.* sp. aff. *biseta* 1 (Jeanes & Backhouse 2006).

The following questions are addressed in this paper:

- Are all current records of *P. xerophila* in Victoria accurately identified?
- What species have been misidentified as *P. xerophila*?
- What is the associated vegetation of *P. xerophila*?
- Are there differences in vegetation associations between *P. xerophila* and *P. lingua* (Large-tongue Rustyhood) in Victoria?

Methods

Field surveys for *Pterostylis xerophila*

Twelve sites within Murray-Sunset National Park, Wyperfeld National Park, Wemen FFR and Mallanbool FFR were surveyed for the presence of *Pterostylis xerophila* during 2009, 2010, 2011 and 2012. These sites included all previous records from Victoria mentioned for this species in Recovery Plans or on herbarium databases. Surveys were conducted during the prime flowering period of this species, October, as plants can only be accurately identified when flowering. Surveys were conducted with botanists and volunteers from the Australasian Native Orchid Society familiar with this and related species. Surveys for the presence of *P. xerophila* and the number of plants at each of the sites were undertaken by walking parallel transects and tracking using GPS coordinates. The transects were walked approximately every 5–10 m throughout suitable vegetation (Cypher 2002), which ensured an adequate survey effort to detect most flowering plants in a given population. In pre-determined survey areas, between 10 and 15 ha were surveyed. Surveys were focussed on the Ecological Vegetation Community (EVC) for which there were anecdotal reports in Duncan (2010) or from which specimens had been previously collected.

Survey site: Murray-Sunset National Park

Eight areas were surveyed within the Murray-Sunset National Park. Three of these also included vegetation surveys on areas where plants were recorded in the previous decade. Surveys took place in 2010, 2011 and 2012. Sites within the Murray-Sunset National Park included three different EVCs. The herbarium collection from Millewa South Bore was collected in an ecotone between Loamy Sands Mallee and Woorinen Sands Mallee. The site surveys in this study were partly concentrated in these two EVCs near the location of the

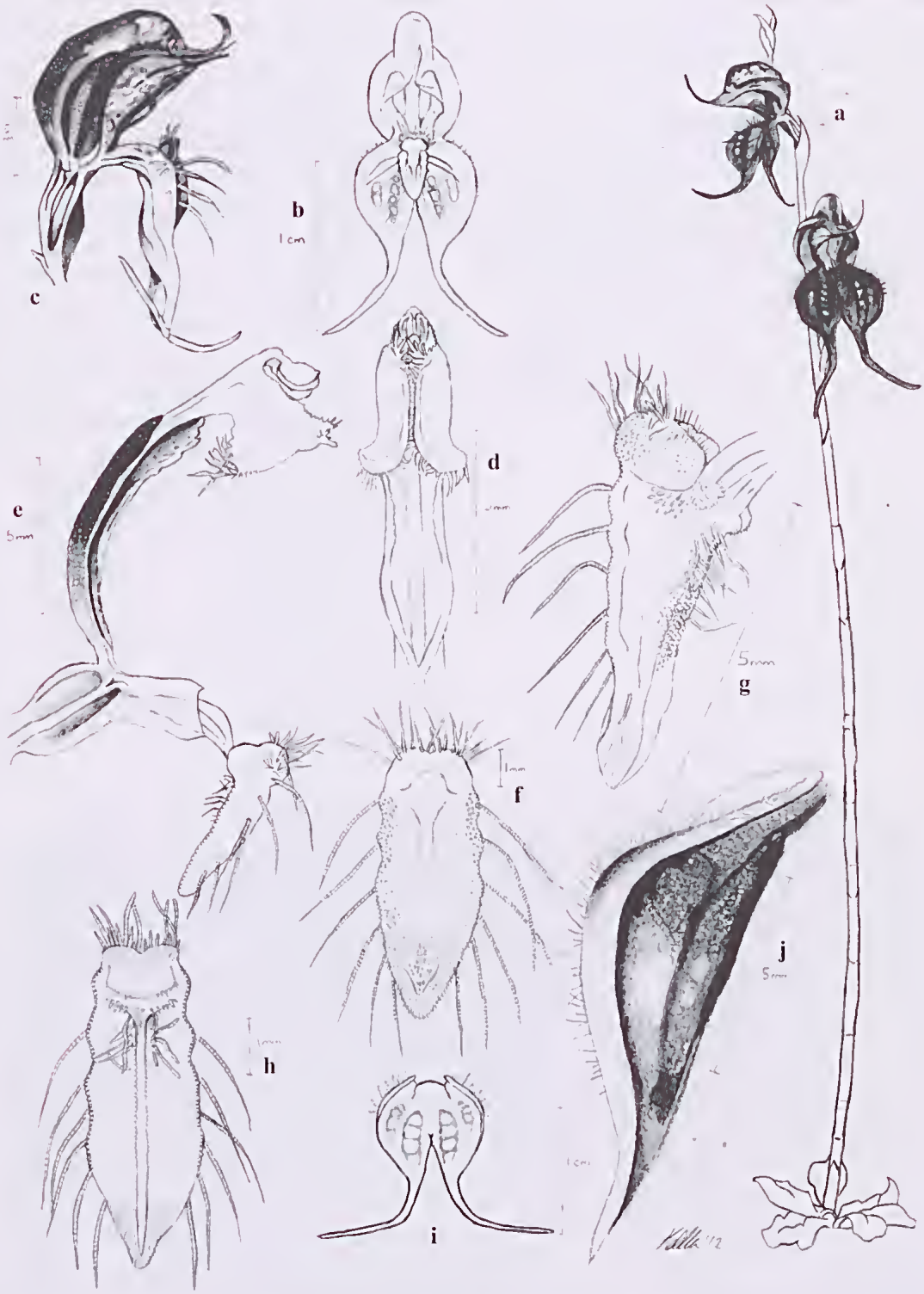

Figure 1. *Pterostylis lingua* from Mallanbool FFR (*N. Reiter and K. Vlcek s.n.* [*ORG 6356*]) **a.** plant; **b.** flower from front; **c.** flower from side; **d.** column from front; **e.** column from side; **f.** labellum from above; **g.** labellum from side; **h.** labellum from below; **i.** lateral sepals from front; **j.** petal. Illustration: K.Vlcek

herbarium collection. A previous unvouchered sighting on Settlement Road in the Murray-Sunset National Park was in the Semi-arid Parilla Woodland EVC.

Survey site: Wyperfeld National Park

There were two survey sites for the presence of *P. xerophila* within Wyperfeld National Park, with volunteers. The survey sites were based on anecdotal information and Recovery Plan (Duncan 2010) information, though not confirmed by previous herbarium records. The two sites surveyed in Wyperfeld National Park were Eastern Lookout, in the EVCs Loamy Sands Mallee and Semi Arid Woodland, and Rudds Rocks, in the EVCs Heathy Mallee and Sandstone Ridge Shrub land. Surveys took place in 2011.

Survey site: Mallanbool FFR

Mallanbool FFR was surveyed extensively with volunteers in 2010 and 2011. The herbarium specimen from Mallanbool FFR had been collected in the Semi-arid Parilla Woodland EVC.

Survey site: Wemen FFR

Wemen FFR was surveyed extensively with volunteers in 2012. The herbarium specimens from Wemen FFR had been collected in the Semi-arid Parilla Woodland EVC.

Vegetation surveys

Vegetation composition for sites at which *P. xerophila* and *P. lingua* occurred was recorded using the line intercept method (Kent & Coker 1992) on twelve 50 m transects (six per species). Additionally, broader species composition was recorded by recording all flora within a 30 m^2 area at all sites where *P. xerophila* and *P. lingua* occurred. The location of each individual *P. xerophila* and *P. lingua* plant was recorded using a GPS and these data were submitted to the Victorian Biodiversity Atlas. Vegetation data was collected from 2010–2012.

Results

Taxonomy

Three specimens lodged under *Pterostylis xerophila* in the National Herbarium of Victoria (MEL) and the Australian National Herbarium, Canberra (CANB) from Murray-Sunset National Park, Mallanbool FFR and Wemen FFR were examined and determined to be *P. lingua*, a species as yet not recognised to occur within Victoria. Further recent collections originally determined as *Pterostylis* sp. aff. *xerophila* from Settlement Road Murray-Sunset National Park (*ORG 6668*) and as *P. xerophila* from Mallanbool FFR (*N. Reiter 103*) and Wemen FFR (*N. Reiter 101*) were also *P. lingua*.

Only one of the four existing herbarium specimens lodged as *P. xerophila* (*Pritchard s.n.* from near Millewa South Bore) was correctly identified, and this species was also re-located in this area during this study.

The two species showed marked morphological differences and displayed consistent differences in their habitat preferences and associated species.

1. *Pterostylis xerophila* M.A.Clem. in Jessop, J.P. & Toelken, H.R. (Ed) (1986), *Flora of South Australia* Edn. 4, 4: 2130, fig. 996

Type: **SOUTH AUSTRALIA.** Cultivated Adelaide ex Wynbring, Great Victoria Desert; on rocky outcrops, 22 Oct. 1978, *R. Bates s.n.* (AD).

Oligochaetochilus xerophilus (M.A.Clem.) Szlach., Polish Bot. J. 46(1): 24 (2001).

Jones, D.L. in Walsh, N.G. & Entwisle, T.J. (Ed) (1994), *Flora of Victoria* 2: 828, Fig. 173s-t.

Pterostylis xerophila is a deciduous, perennial, terrestrial orchid emerging annually from an underground tuber (geophyte). The species is described as follows (Bates & Weber 1990; Jeanes & Backhouse 2006): plants with a ground-hugging, stem-encircling, crowded basal rosette of four to 10 greenish leaves, that are usually withered at flowering time. A slender greenish stem to 20 cm tall, with one or two closely sheathing bracts, bears one to eight small (to 20 mm long), light green flowers with darker green or brownish stripes and suffusions, on long, slender pedicels. The dorsal sepal has an upturned, pointed apex, while the lateral sepals are deflexed, joined at the base, shallowly concave, sparsely ciliate, and taper quickly to slender, curved free points. The labellum is broadly ovate, fleshy and channelled, irritable, and the margins have four or five pairs of coarse white setae.

***Specimen examined*: VICTORIA.** About 7 km SW of Millewa South Bore, 16.x.2005, *A. Pritchard s.n.* [*J.A. Jeanes 1380*] (MEL2296294).

Notes: The treatment of this species in *Flora of Victoria* by Jones (1994) included in the distribution map some collections that we have now identified as *P. lingua*. However, the accompanying illustrations are of *P. xerophila*. Jones (1994) described flower colour as 'reddish brown or brown' but we observed Victorian plants to be green.

2. *Pterostylis lingua* M.A.Clem., *Austral. Orch. Res.* 1: 123, fig. 5A-D (1989)

***Type:* NEW SOUTH WALES**. S end of Cocopara National Park, near Mt. Caley on Barry Scenic Drive, 12 Oct.1986, *R.G.Tunstall 94* (holo CANB!; iso K!, NSW!).

Oligochaetochilus linguus (M.A.Clem.) Szlach., Polish Bot. J. 46(1): 24 (2001).

[*Pterostylis squamata auct. non* R.Br.: Fitzg., Austral. orch. 1(6): [t.6] (1880).]

[*Pterostylis xerophila auct. non* M.A.Clem.: D.L. Jones, Fl. Victoria 2: 828 (1994) pro parte.]

Deciduous herbaceous perennial geophyte. Vegetatively glabrous, with leaves withered at flowering time (Fig. 1a). Roots filamentous with tubers fleshy and globose. Flowering stem simple, erect, 10–30 cm high, with 4–8 sheathing bracts. Rosette stalk 1–3 cm long, leaves 3–12, linear ovate, size extremely variable, margins entire, surface of leaves becoming rugose with age. Flowers 2–8, erect, 1.5–2.5 cm wide, 2–3 cm long, light to dark brown, occasionally dull green with white opaque striping on the galea (Figs 1b, 1c). Buds initially green, later turning brown just before anthesis. Sheathing bracts 4–10, 1–2 cm long. Column (Figs 1d,

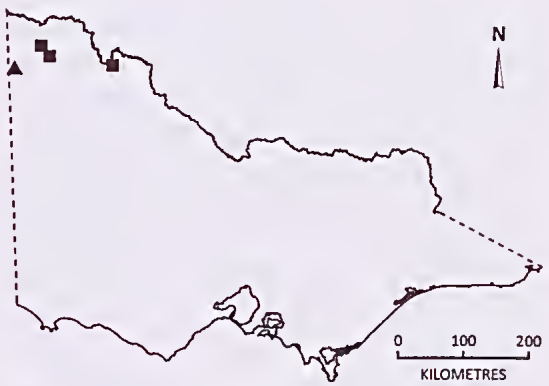

Figure 2. Known distribution in Victoria of *Pterostylis lingua* (rectangle) and *P. xerophila* (triangle)

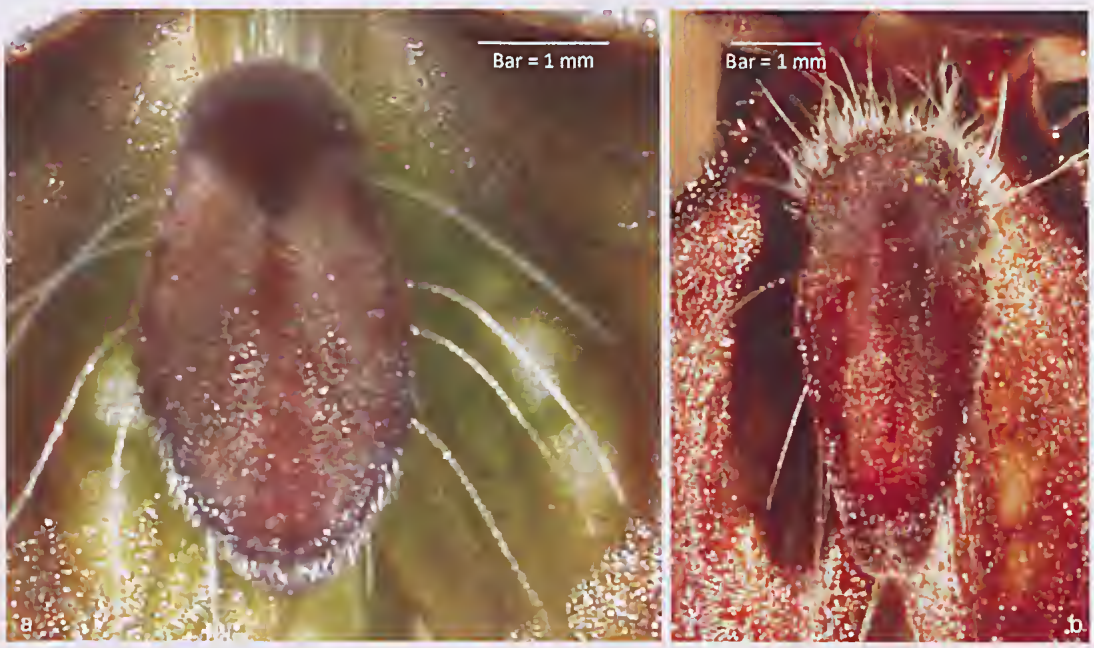

Figure 3. Labellum of **a.** *Pterostylis xerophila* from Murray-Sunset National Park and **b.** *P. lingua* from Mallanbool FFR

1e) 8–15 mm long, curved. Galea arcuate, tips of dorsal sepal and petals not joined. Dorsal sepal 1.5–2cm long, swollen at the base and then long tapered and acute, the tip hooked and variable in length (Fig. 1c). Lateral sepals 1.5–2.5 cm long, 4–6 mm wide, incurved, either the same or slightly longer than the dorsal sepal, tips of lateral sepals becoming involute (Fig. 1i). Petals oblong to falcate 1–1.5 cm long acuminate, 3–4 mm wide (Fig. 1j). Labellum (Figs 1f, 1g, 1h) oblong–sagitate, 4–6 mm long, 2–3 mm wide, light brown to dark brown with darker brown colouring near basal mound and margins. Filamentous part of the lateral sepals variable, greater than 5 mm long, filamentous part of dorsal sepal 1–3 mm. Margins with sparse pilose multicellular trichomes to 3 mm, basal mound 2 mm high. The underside of the labellum is covered by sparse short trichomes to 0.4 mm, basal mound woolly to pilose with multicellular trichomes 1–1.5 mm high. Column wings 2–3 mm wide, 2–3 mm long, dense trichomes to 1 mm long radiate from the margins. Stigma oblong to 3 mm long to 0.5 mm wide with mucilaginous shiny coating. Capsule 1–1.2 cm long, ripening approximately 4 weeks after pollination.

This description and illustration is based on *N. Reiter and K. Vlcek s.n.* [*ORG 6356*].

***Specimens examined*: VICTORIA.** Extreme SW corner of Wemen FFR, 1.3 km along Collins Rd, 10.ix.2004, *M. Duncan s.n.* [*ORG 4558*] (CANB656655); Wemen FFR, 12.xi.1996, *J.McGuckin s.n.* (MEL2037233); same location, 19.x.2012, *N. Reiter 101* (MEL2360816; MEL2360B17); Mallanbool FFR, 3.viii.1999, *M.A.Clements 9917* (CANB664360); same location, 24.x.2011, *N. Reiter and K. Vlcek s.n.* [*ORG 6356*] (CANB); same location, 22.x.2012, *N. Reiter 103* (MEL2360B1B, MEL2360B19); Settlement Road, Murray-Sunset National Park, 24.x.2010, *N. Reiter s.n.* [*ORG 6668*] (CANB; MEL2360820). ORG numbers refer to 'Orchid Research Group' numbers assigned at CANB.

Notes: *Pterostylis lingua* is widespread throughout the western part of New South Wales and also rarely found in the dry inland pastoral region of South Australia.

Field surveys

Pterostylis xerophila was found only within 10 km of the location of the existing herbarium specimen from Millewa South Bore Track in the Murray-Sunset National Park. At sites surveyed on Border track and Millewa South Bore track there were 30 plants of *P. xerophila* in 2009–2010, six in 2011 and one in 2012.

Pterostylis lingua was located at Settlement Road (Murray-Sunset National Park), Mallanbool FFR and Wemen FFR in 2010–2012. Each site contained reasonable numbers (20–1000) of *P. lingua* plants, with 300 plants at Mallanbool FFR and 1000 plants at Wemen FFR. The numbers of flowering plants varied seasonally with no *P. lingua* plants flowering in 2011 on Settlement Road. No plants of *P. xerophila* were found at any of the sites at which *P. lingua* was present.

Pterostylis xerophila was not located within Wyperfeld National Park at the two sites surveyed, Eastern Lookout and Rudds Rocks, previous known sites reported in the 2010 Recovery Plan. Eastern Lookout was severely

Table 1. Vegetation associated with *Pterostylis lingua* and *P. xerophilo* in Victoria

Taxa common to *P. lingua* sites in Mallanbool FFR, Settlement Rd Murray-Sunset National Park and Wemen FFR	Taxa common to *P. xerophila* sites in Murray-Sunset National Park
Acocio oswoldii F.Muell.	*Eucolyptus oleoso* F.Muell. ex Miq
Austrostipo elegontissimo (Labill.) S.W.L.Jacobs & J. Everett	*Eucolyptus sociolis* F.Muell.
Austrostipo scabra (Lindl.) S.W.L.Jacobs & J.Everett	*Triodio scorioso* N.T.Burb.
Casuarino pouper F.Muell. ex L.A.S.Johnson	moss and lichen
Chenopodium curvispicotum Paul G.Wilson	
Chenopodium desertorum (J.M.Black) J.M.Black	
Enchyloena tomentoso R.Br	
Oleoria mogniflora (F.Muell.) Benth.	
Oleorio muelleri (Sond.) Benth.	
Oleorio pimeleoides (DC.) Benth.	
Zygophyllum apiculatum F.Muell.	
moss and lichen	

damaged by goats and no *P. xerophila* or other *Pterostylis* were found at this site; the surrounding fence had fallen into complete disrepair. *Pterostylis* sp. aff. *biseta* a common and widespread species was found at Rudds Rocks.

Vegetation surveys

Plant species common to all sites at which each of *P. xerophila* and *P. lingua* were located within this study are listed in Table 1. Vegetation analysis showed that sites at which *P. xerophila* was present had the following vegetation coverage (highest percentage elements listed): bare ground (in this case rock) 45%, moss and lichen 17%, *Triodia scariosa* N.T.Burb. 12% and the three co-occurring *Eucalyptus* L'Her. species *Eucalyptus gracilis* F.Muell., *E. socialis* F.Muell. ex Miq. and *E. oleosa* F.Muell. ex Miq. total 19%. The vegetation community *P. xerophila* inhabits is a unique ecotone between Loamy Sands Mallee and Woorinen Sands Mallee. The soil was lowan sand with igneous rock intrusions. The vegetation composition of *P. lingua* sites showed the following composition (highest percentage elements): *Casuarina pauper* F.Muell. ex L.A.S.Johnson 14%, *Chenopodium curvispicatum* Paul G.Wilson 7%, *Enchylaena tomentosa* R.Br. 7% and moss 6%. The vegetation community *P. lingua* inhabits is Semi-arid Parilla Woodland.

Discussion

Only 30 plants of *Pterostylis xerophila* were found within the survey areas in the Mallee during the course of this study. Vegetation analysis reveals that *P. xerophila* inhabits a unique ecotone that does not presently fit into any EVC currently listed within the Victorian Mallee (DSE 2011). Populations were confirmed in only the Murray-Sunset National Park. No *P. xerophila* were recorded in Wyperfeld National Park in any surveys during this study, although *Pterostylis* sp. aff. *biseta*, a common and widespread species, was found at Rudds Rocks.

The preferred habitat for *P. xerophila* was determined to be rock outcrops in an ecotone between the EVCs Loamy Sands Mallee and Woorinen Sands Mallee, surrounding rock outcrops with igneous intrusions. This correlates with the habitat for the species found in South Australia where it is reported to occur mostly in sand adjacent to rock outcrops but also on the rock outcrops themselves in shallow soils (Bates 2012).

Pterostylis lingua is associated with the ecological vegetation class Semi-arid Parilla Woodland in the Murray Mallee Bioregion. Semi-arid Parilla Woodland as an EVC in Victoria is considered 'vulnerable' (DSE 2011). *Pterostylis lingua* is known from scattered populations from Cootamundra to Bourke in New South Wales and dry eastern slopes and foothills of the Flinders Ranges across the Olary Spur in South Australia. The species is known to occur in a variety of vegetation types including *Callitris* woodland, *Eucalyptus* woodlands and native grasslands.

Distinguishing Desert Greenhood from Large-Tongue Rustyhood

Pterostylis lingua is similar to *P. xerophila* but easily distinguished based on the labellum, which has a densely pubescent basal mound and flattened margin towards the apex, which *P. xerophila* does not (Fig. 3). Plants also typically have four or more widely spaced flowers and are found growing in Semi-arid Parilla Woodland, whereas *P. xerophila* is typically found on semi-exposed rock outcrops and generally only has one to two flowers per stalk. The species have not been found to co-occur. Both species are easily distinguished from other similar Victorian orchids. Sikh's Whiskers (*P. boormanii* Rupp.) has heavily ciliated, winged sepals that are distinctly cupped and Two Bristle Greenhood (*P.* sp. aff. *biseta*) (Jeanes & Backhouse 2006) has much longer lateral sepals and distinctly paired setae at the base of the labellum.

Conservation status

It is recommended that, based on the survey data in this study and current known population sizes for *P. xerophila* in South Australia, the species be upgraded from 'vulnerable' to 'endangered' under the *Commonwealth Environment Conservation and Biodiversity Protection Act*, due to lower numbers of individuals than previously anticipated in Victoria and relatively restricted suitable intact habitat.

Pterostylis lingua is a new species record for Victoria with a limited distribution in north-west Victoria, known with certainty from only a few populations and less than 1500 individuals; the conservation status of this species is considered 'vulnerable' within Victoria.

Conclusions

The range of *Pterostylis xerophila* in Victoria is more restricted than previously reported by Duncan (2010), due to the mis-identification of specimens from other sites such as Mallanbool FFR and Wemen FFR, which are in fact *P. lingua*. The species is confirmed as present in only a small area within the Murray-Sunset National Park.

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Gynodioecy in *Teucrium racemosum* (Lamiaceae)

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Introduction

When describing *Teucrium albicaule* Toelken, the author drew attention to its gynodioecy and intimated that some 'atypical' specimens of *T. racemosum* R.Br may represent male-sterile plants of that species (Toelken 1985). While collecting in remnant native vegetation of the lower Avoca Plain between Kerang and Quambatook in May 2012, we observed extensive clonal populations of a small-flowered *Teucrium* L. in general habit like *T. racemosum*, typical forms of which were common and also extensively clonal in the area. The staminal filaments of the small-flowered plants were barely longer than the corolla tube while those of typical *T. racemosum* are much longer than the corolla tube (Figs 1, 2). The habitat at the site is an extensive grassland/low shrubland developed on red clay, ranging from hard-setting compact clay to self-mulching/cracking clay. Topography is generally flat, but shallow gilgais and puffs are present. Annual rainfall is approximately 350 mm.

Results and discussion

The small-flowered plants conformed to what had been described as *Teucrium racemosum* var. *polymorphum* Tovey & P.Morris (1922). Alternatively, such plants had been suggested by Conn (1999) to be hybrids between *T. racemosum* and *T. albicaule*. However, *T. albicaule* is a very rare species in the lower Avoca Plain area and its nearest occurrence is about 10 km from the small-flowered population of *T. racemosum*. At this site, *T. albicaule* is near its most easterly known occurrence in Victoria, and at least 100 km from the next known occurrence. Apart from the small flowers, there are no traits of these populations that suggest any parental contribution from *T. albicaule*, although apparent genuine hybrids between these two species are known from further north and west of the Kerang area. The leaves of the small-flowered plants are undivided and elliptic-ovate rather than trifoliolate with linear leaflets, and are generally significantly longer than the upper limit (10 mm) ascribed to *T. albicaule*. A simpler explanation for these small-flowered plants is that *T. racemosum*, like *T. albicaule* is also gynodioecious, according with Toelken's (1985)

Abstract

Clonal populations of small-flowered plants of *Teucrium racemosum* R.Br from north-western Victoria were examined, and gynodioecy suggested as the simplest explanation for their form and distribution. *Teucrium racemosum* var. *polymorphum* Tovey & P.Morris and *T. racemosum* var. *triflorum* J.M.Black are consequently placed in synonymy under *T. racemosum*.

Key words: male-sterile, clonal populations, grassland

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suggestion, but apparently not confirmed in this species before. Examination of *T. racemosum* specimens at MEL revealed plants of this flower type also occur in Western Australia, Northern Territory and New South Wales (see below, and e.g. Conn 2012, Figs 1 & 2). It is possible that similar plants are to be found through the entire range of *T. racemosum*. The main floral differences between the hermaphroditic and female forms are summarised in Table 1.

Close inspection found anthers of the small-flowered form to be empty or with only small amounts of relatively small pollen grains (av. 30.4 ±1.7 x 29.5 ± 0.4 microns, Fig. 3), including many misshapen grains. This supports the notion that these are female plants, or at least have a reduced male function. Hermaphroditic flowers from the same area had abundant, normal-appearing pollen (av. 44. 6 ± 2.3 x 47.1 ± 1.7 microns, Fig. 4). It was noticed in the field (and evident on herbarium collections made from these plants) that the small-flowered plants were relatively prolific in producing fruit. A cursory inspection of the sympatric large-flowered (and presumably hermaphrodite) plants detected none of these to be forming fruit, although examination of *T. racemosum* specimens at MEL shows that fruits are produced by large-flowered plants also. Despite the comment by Cunningham *et al.* (1992) that plants of 'var. *polymorphum*' (i.e. those plants here believed to be female) produced fewer mericarps, our collections showed that the plants typically matured all four mericarps per flower. We assume that seed production is a consequence of pollen being transferred from hermaphroditic to female plants, but the possibility of apomixis cannot be discounted without further investigation. Apomixis has been reported in *Thymus loscosii* Willk. (Orellana *et al.* 2005), another gynodioecious member of the Lamiaceae.

Observations across the Riverina over many seasons by one of us (EOB) suggest there is normally little overlap in flowering times of the two forms, with the male-sterile form typically flowering in cooler seasons (autumn and

Figure 1. Small-flowered (female) form of *Teucrium racemosum* (= var. *polymorphum*) from the lower Avoca Plain (*N.G. Walsh 7557 & E. O'Brien* (MEL))

Figure 2. Typical, hermaphroditic *Teucrium racemosum* sympatric with the female form shown in Fig. 1 (*N.G. Walsh 7558 & E. O'Brien* (MEL))

spring) while the large-flowered form typically flowers during summer, particularly following summer rain. The unusually wet summer/early autumn of 2012 appears to have prolonged flowering of the large-flowered form resulting in a considerable period of overlap in anthesis of the two flower types. There is also an interesting observed difference in the distribution of both forms in relation to soil type, with the male-sterile form almost exclusively inhabiting hard-setting (infrequently cracking) clay/clay-loam, and the hermaphrodites on the softer, self-mulching clays and loams. This soil type preference may help explain the observed difference in peak flowering times between the male-sterile and hermaphrodites as the different soil types respond very differently to seasonal rainfall events.

Genetic studies on *Arabidopsis thalliana* (L.) Heynh. (Brassicaceae) have shown that a gene linked to pistil development is negatively associated with corolla development (Weigel & Meyerowitz 1993) suggesting a reason why female flowers commonly have smaller corollas than hermaphroditic flowers of the same species (Delph 1996). It is a possible explanation for the floral pattern displayed by *Teucrium racemosum*.

It would appear from herbarium collections held at MEL that male-sterile plants are relatively uncommon. Only five specimens (including the type of var. *polymorphum*) were of this form amongst 294 specimens from all Australian mainland states at MEL (non-flowering specimens however were not determinable as to flower type). However, observations through the Riverina area of New South Wales and Victoria (*sensu* IBRA 2012) indicate that both forms are common in grasslands. Perhaps the smaller-flowered plants are overlooked or avoided by collectors on the assumption that flowers are simply not yet fully formed.

Gynodioecy is relatively common in Lamiaceae, and members of this family were among the first plants to be studied by Charles Darwin when he first described this phenomenon (Darwin 1877). It has generally been believed that gynodioecy is derived from the

Table 1. Summary of major floral differences between hermaphroditic and female *Teucrium racemosum*

	Hermaphrodites	Females
Pedicel length (mm)	8–18	2–6
Calyx length (mm)	4.5–6	2.5–4.5
Corolla dorsal lobe length (mm)	3–5	1.5–2
Corolla median ventral lobe length (mm)	6–12	3–5
Filament length (mm)	9–11	1.5–3.5
Style length (mm)	10–13	4–5

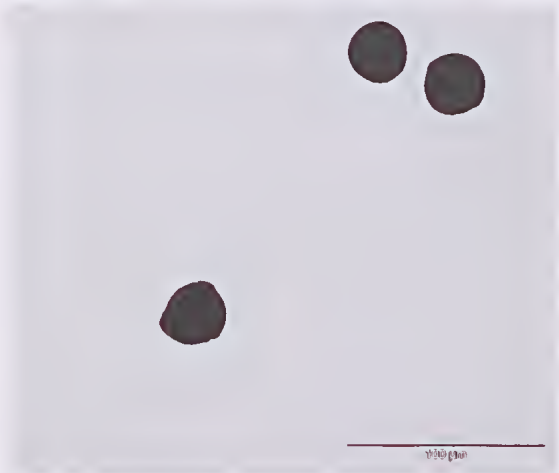

Figure 3. Pollen of small-flowered (female) form of *Teucrium racemosum* stained in Methylene Blue (scale bar = 100 µm; from *N.G. Walsh 7557 & E. O'Brien* (MEL))

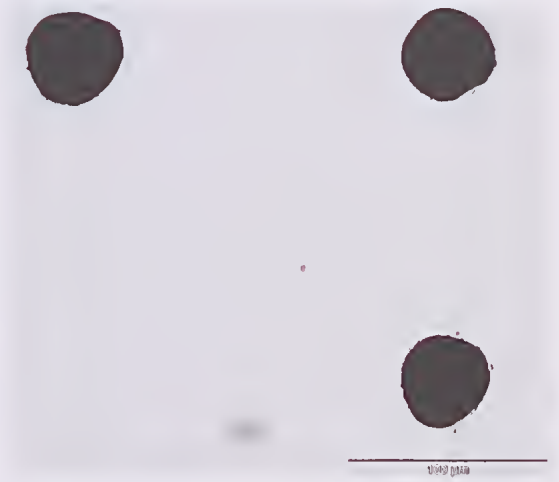

Figure 4. Pollen of hermaphroditic *Teucrium racemosum* stained in Methylene Blue (scale bar = 100 µm; (from *N.G. Walsh 7558 & E. O'Brien* (MEL))

hermaphroditic state, rather than being derived from, or giving rise to dioecy (*e.g.* Lewis 1942). However, Ross (1978) proposed mechanisms whereby gynodioecy may be transitional toward dioecy from the conventional hermaphroditic condition, albeit via more complex genetic processes.

Several studies across a wide range of families suggest that the female plants may compensate for the absence of male function by possessing traits that, for example, increase floral longevity (Petterson 1992), reduce likelihood of inbreeding depression (Lloyd 1975; Charlesworth & Charlesworth 1987) or elevate levels of seed production (Lewis 1941; Lloyd 1976). Observation suggests that the latter trait is being expressed at the Avoca Plain site at least.

Taxonomy

Teucrium racemosum R.Br. *Prodr.* 504 (1810)

Type: **SOUTH AUSTRALIA.** Spencers Gulf, 1802, *R. Brown* (holo: BM; iso: CANB).

Teucrium racemosum var. *polymorphum* Tovey & P.Morris, *Proc. Roy. Soc. Victoria* new ser. **35**, 89 (1922). *Type:* Victoria. Kerang, Sept. 1920, *E.J. Semmens* (holo: MEL!).

Teucrium racemosum var. *triflorum* J.M. Black, *Fl. South Australia* 3: 486 (1926). *Type:* South Australia: Eringa near Lindsay Creek, 3.X.1913, *White s.n.* (holo: AD, photo seen).

Teucrium sp. B. *sensu* Jacobs, S.W.L. & Pickard, J. (1981), *Plants of New South Wales, fide* Conn (2012),

Specimens seen: ('var. *polymorphum*' form = female-flowered plants): **WESTERN AUSTRALIA.** (Geraldton Sandplains, *sensu* IBRA 2012) 10 mile (16.1 km) peg along main road to Kalbarri from North West Coastal Highway, December 1918, *E. Officer 9/19* (CANB, MEL, NSW). **NORTHERN TERRITORY.** (Finke, *sensu* IBRA 2012) Jimmys Dam, 23 km ESE Erldunda Homestead, 26.vi.2000, *P.K. Lotz 16361* (MEL, NT). **NEW SOUTH WALES.** (Nandewar, *sensu* IBRA 2012) Red Bobs Reserve, c. 40 km SW of Gunnedah, 30.i.2005, *J.R. Hosking 2580* (CANB, MEL, NE, NSW). **VICTORIA.** (Riverina, *sensu* IBRA 2012) Kerang, Victoria, September 1920, *E.J. Semmens 72* (MEL – type of var. *polymorphum*); 26.5 km due W from Kerang, 29.iv.2012, *N.G. Walsh 7557, J.P. Walsh & E. O'Brien* (AD, CANB, MEL, PAL); (Murray Darling Depression) 17.9 km SW of Birchip, 5.x.2011, *M.Argoll s.n.* (MEL).

Note: Cunningham *et al.* (1992) report occurrences in south-western New South Wales in the Hay, Wanganella and Jerilderie districts, all within the Riverina region (*sensu* IBRA 2012).

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The mycorrhizal associations of *Borya mirabilis*, an endangered Australian native plant

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Introduction

The genus *Borya* Labill. was described in 1805, based on the Western Australian species *B. nitida* (Labillardiere 1805). *Borya* was long included in the Liliaceae but was subsequently placed in the tribe Boryeae within the family Boryaceae (Baker 1879). Placement in the Boryaceae, with one other genus *Alania* Endl., has been confirmed by molecular studies (Chase *et al.* 1996). *Borya* species are considered desiccation tolerant and lose most of their chlorophyll and thylakoids when dehydrated and can survive the loss of up to 94% of their water (Porembski & Barthlott 2000).

Thirteen species of *Borya* have been described, three of which are threatened (Reiter 2008). The greatest diversity occurs in mediterranean south-western Western Australia (Reiter 2008) and in tropical Australia (Western Australia, Northern Territory and Queensland) with four species. Only *B. mirabilis* has a south-eastern Australian distribution. This species is confined to the Grampians (Gariwerd) National Park approximately 250 km north-west of Melbourne. Currently only one natural population of the species is known, in the Wonderland Range, with a second, translocated, population some 15 km north of this in the Mt Difficult Range. Despite close monitoring since its description (Churchill 1985), there has been no production of viable seed in *B. mirabilis* and the sole population is believed to comprise a single clone or plants that are so genetically similar that they are incapable of sexual reproduction (Coates *et al.* 2002). As a consequence it is one of Australia's most endangered plants.

Borya mirabilis is listed as endangered nationally under the *Environment Protection and Biodiversity Conservation Act 1999* and in Victoria is listed as a threatened taxon under the *Flora and Fauna Guarantee Act 1988*. An *ex-situ* population established at the Royal Botanic Gardens Melbourne (RBG) is of particular importance. A National Recovery Plan has been prepared (Coates *et al.* 2002) and a recovery team has been formed to

Abstract

The mycorrhizal associations of *Borya mirabilis* Churchill, T.B.Muir & Sinkora are described for the first time, based on seasonal observations over 12 months. Roots of vascular plants associated with *B. mirabilis* in the field were also examined for mycorrhizal associations; *Callitris rhomboidea* R.Br. ex Rich. & A.Rich. was found to be most morphologically similar. The usefulness of associated plants to inoculate *ex-situ* populations and as indicators of potential translocation sites for *B. mirabilis* is discussed.

Key words: Boryaceae, arbuscular mycorrhizae, propagation.

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implement the recovery plan, in particular, to increase the number of plants in cultivation and to establish self-sustaining translocated populations in the wild. However, management is hampered by a lack of basic knowledge about growth requirements, particularly in relation to mycorrhizal associations, media requirements and reproductive biology.

Mycorrhizal associations are of particular importance in the management of any plant species. No studies on the mycorrhizae of *Borya* species have been published; however, Keighery (1984) refers to Western Australian *Borya* species as being both ectomycorrhizal and arbuscular mycorrhizal.

The fungi that form arbuscular mycorrhizae (AM) are biotrophs. They provide a direct link between plant roots and the soil (Smith & Read 1997). Benefits of AM include increased phosphorous uptake (George *et al.* 1992; Titus & Lepš 2000); increased uptake of nitrogen, magnesium and iron (Fitter & Merryweather 1992; Barea & Jeffries 1995; Varma 1995), zinc and copper (Marschner 1995); increased resistance to stress, pathogens, heavy metals, acidity and salinity (Pfetffer & Bloss 1988; Dodd *et al.* 1990; George *et al.* 1992; Barea & Jeffries 1995; Marschner 1995); changing compounds in soil to easily absorbed forms (Leyval & Berthelin 1989; Knight *et al.* 1989; Marschner & Dell 1994); and general increased plant size and vigour (Grime and Hodgson 1987; Smith & Read 1997; Bohrer *et al.* 2003; van der Heijden *et al.* 2003). Ectomycorrhizae (EM) are symbiotic mycorrhiza, which differ from AM in having septate hyphae a Hartig net and extracellular mantle (Brundrett 2008). Similar benefits have been found with EM as in AM (Buscot *et al.* 2000).

Arbuscular mycorrhizae can be assigned to three morphological types: Arum type, Paris type, and a third type known as *Rhizophagus* or *Endogone* mycorrhizae. This third group of AM is associated with plants that form nodular structures on their roots (Saxton 1930; Béreau & Garbaye 1994). The following questions are addressed in this paper:

1. What type(s) of mycorrhizae does *Borya mirabilis* form and how does this alter seasonally?
2. Do the fungi provide a beneficial relationship to *Borya mirabilis* when growing together?
3. What mycorrhizal associations do associated plants in the field have?

Material and methods

Borya mirabilis field sampling

Root samples from *Borya mirabilis* were collected each season over a 12-month period from the one known field site. Three 50 g samples of roots and soil were collected from four different colonies each season. Samples were stored in 50% ethanol and taken back to the laboratory for clearing and staining. Root samples were gently rinsed in tap water and placed in 10% potassium hydroxide, warmed to 90°C for a period of two hours and left to cool and clear for 30 minutes. The roots were then rinsed twice in distilled water for five minutes, placed in warm lacto-fuchsin (Carmichael 1955) for five minutes and cleared in three changes of 60°C glycerol over several days and finally stored in 50% glycerol for examination (Brundrett 2008). Thirty root samples were randomly chosen from each processed 50 g sample. The roots where then observed under a light microscope. Root morphology, type of mycorrhizae present and infection percentage were recorded. Mycorrhizae were divided broadly into four groups: ectomycorrhiza; arbuscular mycorrhiza; ericoid mycorrhiza and orchid mycorrhiza. The division was based on characters that define these groups (Brundrett 2008) including: the presence or absence of septate hyphae; a sheath; hyphae inside plant cells and hyphal coils or arbuscules. The percent mycorrhizal infection of each of these roots was determined by determining the total root area using a micrometer, dividing this by the area infected with mycorrhizal fungi and multiplying by 100.

Mycorrhizal pot trials

Root samples of *B. mirabilis* were taken from the field site and used to inoculate three pots of *B. mirabilis* in the *ex-situ* population at the Royal Botanic Gardens Melbourne. Pots were left for three months to allow time for root infection. The roots and soil of these plants were then used to inoculate the *ex-situ* population, with 11 plants being inoculated and 11 left as controls. Plants were re-potted in sterile potting media, with a layer of glass beads over the surface to prevent infection of the soil by air-borne fungal spores. A sealed watering tube was inserted so plants could be watered with sterile water.

Potential infection by *Phytophthora cinnamomi* Rands was controlled in two ways. Firstly, field samples

were taken from *B. mirabilis* plants which appeared uninfected by *P. cinnamomi* and all field equipment and shoes were sprayed with Phytoclean on entering and exiting the site. Secondly, plants inoculated with field soil and roots were treated with furalaxyl and metalaxyl in order to kill any *Phytophthora* that may have been present in the soil.

Plants from both treatments were housed in a quarantine greenhouse at the Royal Botanic Gardens Melbourne and in all other respects were treated equally. Plants were monitored once a month for six months and the number of shoots and leaf colour were recorded. At the conclusion of the trial, root samples were taken. They were cleared, stained and viewed for the presence/absence of mycorrhizae, using the same methodology as for field sampled roots. The results were analysed by ANOVA using Minitab 14© software.

Associated species mycorrhizal examination

Vascular plant species associated with *B. mirabilis* in the field were previously identified during an ecological study conducted on the site (Reiter 2008), During winter, three root samples from each of three individual plants from 19 species associated with *B. mirabilis* in the field were taken. Several additional seasonal species and the other threatened plant species on the site were not examined due to low numbers of these species on the site. The associated mosses on the field site were not examined, as mycorrhizal associations have never been observed in mosses (Read et *al.* 2000; Davey & Currah 2006).

All associated plants that were sampled occurred within 10 m of *B. mirabilis* plants. Plant roots were stored in 50% ethanol, cleared, stained as with *B. mirabilis* (with the exception that tougher roots required longer clearing, depending on the species) and examined for the presence of mycorrhizae. Plants infected with ectomycorrhizae (EM) were embedded in wax and cross-sectioned to observe internal structures (Reiter 2008). Thirty slides from each associated species were examined and the type of mycorrhizal infection recorded. The mycorrhizal type was determined as AM, EM, ericoid or orchid, based on septation of the hyphae, presence of hyphal coils (absent in EM), presence or absence of arbuscules and vesicles (characteristic of AM) and presence or absence of a mantle and Hartig net (characteristic of EM), as well as the host family, following Harley and Smith (1983), Schüßler (2002) and Selosse *et al.* (2007).

Results

Borya mirabilis field sampling

The roots of *Borya mirabilis* contained small nodules along the lengths of the lateral roots, matching those described in 'Endogone-type' AM. These nodules had indeterminate growth and would often appear on top of each other as offshoots (Fig. 1).

Examination of roots over each season throughout the year showed clearly that the roots of *B. mirabilis* were predominantly associated with AM, but some EM were also present. The AM appeared as spores within the nodules on the roots in summer (Fig. 1), and as coils contained inside the nodule cells in winter (Fig. 1). The EM structures observed were predominantly of the *Cenococcum* type. Infection by AM was greater in winter and spring than in summer and autumn; while infection by EM was highest in autumn and winter (Table 1).

Mycorrhizal pot trials

Both inoculated and control plants were healthy after six months. The shoot number of inoculated plants was greater than un-inoculated plants (Fig. 2) with an ANOVA P value of 0.07.

Table 1. Mycorrhizal associations of *Borya mirabilis* over one year, showing average infection of 30 roots from each season and the type of arbuscular mycorrhizal infection

Season	Mean total % infection	Mean % infection AM	Mean % infection EM	AM structures
Summer	0.8 ± 0.24	0.43	0.37	Spores
Autumn	7.8 ± 0.88	4.6	3.2	Spores and coils
Winter	17.6 ± 0.87	14.9	2.7	Coils
Spring	12.4 ± 0.92	12	0.4	Coils

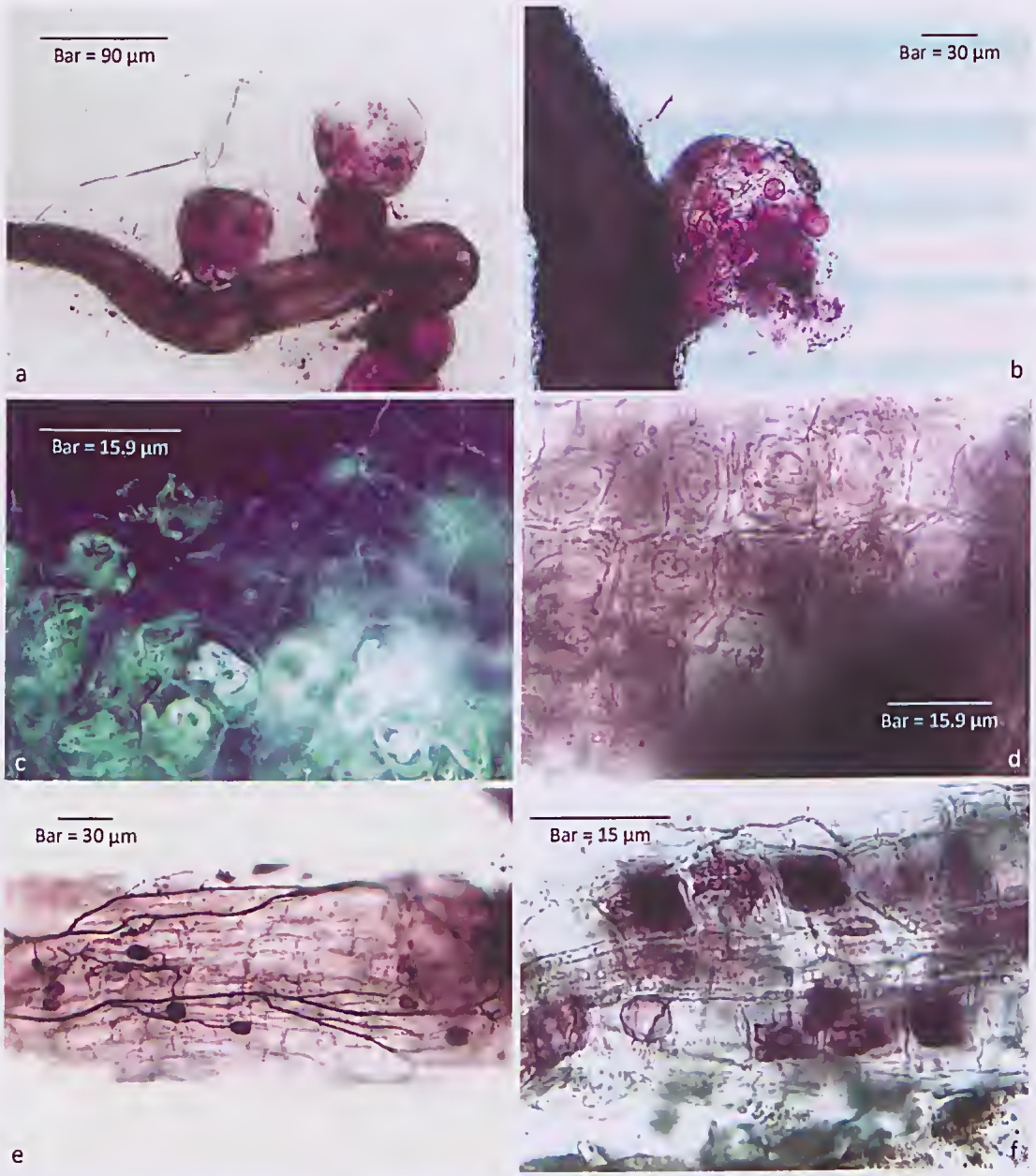

Figure 1. a. Low-power light microscope image of *Borya mirabilis* lateral root with nodular offshoots, showing indeterminate growth; **b.** *B. mirabilis* root sampled in summer, with nodule containing spores consistent with endogone-type mycorrhizal infection; **c.** *B. mirabilis* root sampled in winter with nodule containing endogone-type arbuscular mycorrhizal coils; **d.** Paris-type arbuscular mycorrhizae in *Callitris rhomboidea* roots collected from *B. mirabilis* field site; **e.** arbuscular mycorrhizae in roots of *Acacia stricta* collected from from *B. mirabilis* field site; **f.** arbuscular mycorrhizae in *Themeda triandra* roots collected from *B. mirabilis* field site

Associated species mycorrhizal examination

Of the 19 associated species from the *B. mirabilis* field site, 12 had AM (Table 2). Of these, *Callitris rhomboidea* (Fig. 1) displayed the most morphologically similar mycorrhizal association to that observed for *B. mirabilis*, with a Paris-type association. The other plants that displayed AM in the majority of slides examined were *Acocio stricta* (Andrews) Willd. (Fig. 1), *Dodonaeo viscosa* (L.) Jacq., *Kunzea parvifolia* Schauer, *Leptospermum scoporium* J.R.Forst & G.Forst and *Themeda triandra* Forrsk. (Fig. 1). *Grevillea aquifolium* Lindl. had proteoid roots, but *G. alpino* Lindl. had AM and EM.

Discussion

We have demonstrated for the first time that *Borya mirabilis* has a mycorrhizal association and that it is typical of the nodular AM (Endogone type) association. While EM associations were found, they were in low numbers, particularly over spring when the *Borya* plants were actively growing (Table 1). Nodular formations on

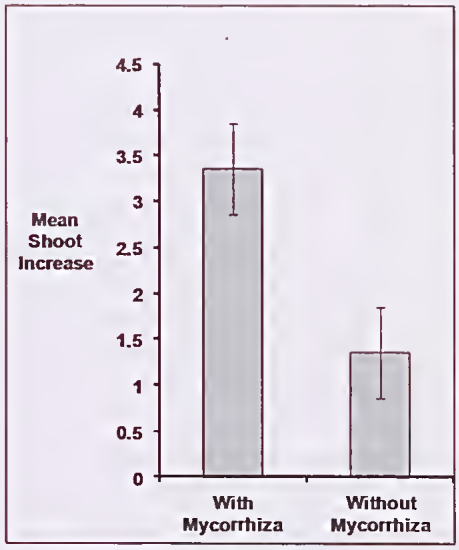

Figure 2. Mean shoot increase over six months of *Boryo mirobilis* plants inoculated with mycorrhizal roots and those without. Bars refer to 2x standard error of the mean of each treatment

Table 2. The presence of different types of mycorrhizae or proteoid roots in plant species associated with *Boryo mirobilis* in the field; the dominant type shown as ++

Species	EM	AM	Ericoid	None	Orchid	Proteoid Root
Acocio stricto	+	++				
Rytidospermo setoceum				++		
Collitris rhomboideo		++				
Colytrix tetrogono	+	+				
Dodonoeo viscoso	+	++				
Drosero oberrons				++		
Eucolyptus olaticoulis	++	+				
Gonocorpus mezionus	+	+				
Grevilleo oquifolium						++
Grevilleo olpino	++	+				
Kunzeo porvifolio	+	++				
Lepidosperma viscidum				++		
Leptospermum scoporium	+	++				
Leucopogon virgotus			++			
Meloleuco decussoto	+					
Phyllonthus hirtellus	++	+				
Thelymitro ixioides					++	
Themedo triondro		++				
Thryptomene colycino	++	+				

Present on site but not examined: *Centrolepis oristoto*, *Centrolepis strigoso*, *Drosero peltato* subsp. *ouriculata*, *Austrostipa hemipogon*.

Boryo roots or the AM association residing inside have not been reported previously.

Arbuscular mycorrhizal fungi, usually belonging to the Glomales, are associated with plant roots forming mycorrhizal nodules (Huguenin 1969). These nodule-inhabiting mycorrhizae are associated with many species in the Podocarpaceae (Saxton 1930; Morrison 1963), Araucariaceae, Phyllocladaceae and Casuarinaceae and the Caesalpiniodeae in the legumes (Béreau & Garbaye 1994). This type of AM mycorrhiza is characterised by the cortex of the root being colonised, but without any association in the endodermis. The cortex is also surrounded by a periderm that contains several layers of dead cells (Duhoux *et al.* 2001), unlike normal AM associations, which only infect unsuberised roots (Duhoux *et al.* 2001).

The nodular roots of *B. mirabilis* do not have determinate development, unlike most nodular mycorrhizal associations (Duhoux *et al.* 2001). In *B. mirobilis* a new nodule can form from the tip of old nodules, leading to an elongated moniliform nodular lateral root. *Gymnostoma nodiflorum* (Thunb.) L.A.S.Johnson (Casuarinaceae) is one of the few plant species with nodular mycorrhizal roots that also has the ability to reactivate the apical meristem to extend its lateral roots (Duhoux *et al.* 2001).

This is the first report of seasonal changes in the AM structures associated with *Boryo* species or nodulated AM species. It would therefore be interesting to see if these same seasonal changes occur in other *Boryo* species and if the morphological seasonal changes still occurred if plants were not allowed to go through their desiccation-tolerant phase in summer, in *ex-situ* conditions.

The addition of nodule-inhabiting AM fungi from the field site of *B. mirabilis* to the *ex-situ* population improved plant growth. Benefits of *Endogone*-type (nodule-inhabiting) AM, including increased growth, health and nutrient uptake, have been documented previously (Baylis 1959).

Arbuscular mycorrhizae cannot currently be cultured asymbiotically. They require host roots to remain viable. This poses difficulties for developing plans to enhance the recovery of the *B. mirobilis* population, not only in the *ex-situ* collection, but also in the reintroduction sites. For the *ex-situ* population, it is suggested that the mycorrhizal fungi from the field be introduced and kept in labelled pots, and that roots from these plants be used to inoculate cuttings as they become available. In this way, plants translocated to external sites could be inoculated with beneficial mycorrhizal fungi that will presumably aid their establishment and growth. The collection of endangered plant roots, especially from a field site that is infected with *Phytophthora cinnamomi*, is not a viable means of introducing mycorrhizal fungi to *ex-situ* populations.

The most similar mycorrhizae among the associated species was that of *Callitris rhomboidea*. The AM of *C. rhomboidea* have not been described previously. However, Pattinson *et al.* (2004) found that the species produced AM when inoculated with arbuscular mycorrhizal fungi. Other *Collitris* species are well known for forming AM. In particular, *Collitris glaucophyllo* Joy Thomps. & L.A.S.Johnson has AM that are morphologically similar to that found on *C. rhomboideo* (Dickson *et al.* 2007). Presence of AM in *C. rhomboideo* means that it could be used as a source of inoculum for pots and as an indicator of suitable translocation sites for *B. mirabilis*, although trials are needed with *ex-situ* plants to see if cross-innoculation or translocation would be beneficial.

The majority of mycorrhizal associations among associated plants from the *B. mirabilis* field site were consistent with reports of known mycorrhizal associations (Brundrett 2008). There were, however, several unexpected results. In particular, *Grevilleo olpino* (Proteaceae), which would be expected to have proteoid roots and thus no mycorrhiza, was found to have an EM and AM associations. However, it is not alone in the Proteaceae in having an AM association; these associations have also been recorded in *Bonksio ericifolia* L.f. and *Telopeo speciosissima* (Sm.) R.Br. (Wang & Qiu 2006).

Future work on the nodular mycorrhizal associations of *B. mirobilis* should more precisely determine the structure of the AM fungi inside the nodules and should also attempt to identify the fungi responsible by DNA analysis. Such analysis will require careful washing and removal of the nodules before extraction, preferably with fresh material, which may increase the initial concentration of fungi in the extract compared to plant DNA. Amplification of Glomalean AM fungi has already

been successfully achieved from nodular mycorrhiza of *Gymnostoma* (Duhoux *et al.* 2001).

With the aid of molecular identification, the fungi in the AM that was associated with the species in the field and was beneficial in the *ex-situ* collection could be identified. Further research could then test to see if the same fungus is present in mycorrhizae of other associated species that have been shown to form AM associations, in particular *Callitris rhomboidea*. If this is the case, then the roots of these non-endangered species could be used for further fresh inoculations of the mycorrhiza from the existing field site to the *ex-situ* population.

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